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Energy Efficient Food Preparation Equipment, Processes and Procedures in Restaurants

A RESEARCH REPORT

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Energy Efficient Food Preparation Equipment, Processes and Procedures in Restaurants

A RESEARCH REPORT

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Prepared by the
Office of Industrial Research
Department of Mechanical Engineering
University of Manitoba

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ABSTRACT

Key Words: Cooking equipment/food preparation/
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training/human resources/cooking methods/
cooking procedures

The study, based on data up to 1983, provides a general overview of restaurant equipment, processes and procedures that are valuable to the restaurant owner or manager. Heat transfer and efficient methods of using food preparation equipment are discussed in relation to food quality. The conclusions are compiled in an application guide which matches energy efficient equipment to food preparation procedures. A human resource section is included to assist the restaurant owner in the difficult task of introducing energy efficient procedures to staff. The study presents a comprehensive view of food preparation equipment, processes and procedures and shows a need for further investigation in several areas. Among these is a comparison of high- and low-temperature dishwashers and a summary of the cost of gas and electricity across Canada. A workshop module and a detailed section in the restaurant manual also should be developed from the information in this study.

RESUME

Mots clés : Équipement de cuisine, préparation des aliments, restaurants, économie d'énergie, formation du personnel, ressources humaines, méthodes et procédés de cuisson.

L'étude, qui se fonde sur des données amassées jusqu'en 1983, donne un aperçu général de l'équipement et des méthodes et procédés qui présentent un intérêt pour le propriétaire ou le gérant d'un restaurant. Le transfert de chaleur et diverses façons efficaces d'employer les ustensiles et appareils de préparation des aliments sont traités dans l'optique de la qualité des aliments servis. Les conclusions tirées sont compilées de manière à constituer un guide indiquant les appareils et ustensiles qui donnent le meilleur rendement énergétique pour divers procédés de cuisson.

Une section relative aux ressources humaines aidera le propriétaire de restaurant à présenter à son personnel, les méthodes et moyens d'améliorer le rendement énergétique de son entreprise.

Il ressort par ailleurs d'un examen détaillé du matériel, des procédés et des méthodes de préparation des aliments qu'il faudra approfondir davantage certains aspects de la question et, notamment, comparer le rendement de lave-vaisselle dont l'eau est chauffée à des degrés différents et faire un relevé sommaire du coût du gaz et de l'électricité d'un bout à l'autre du pays. Il conviendrait également de tenir un atelier sur le sujet et d'ajouter un chapitre au guide intitulé *Economies d'énergie et profit$ à la carte*, à partir des renseignements fournis ici.

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1.0 PREFACE

This report was prepared by the Restaurant Sector of the Buildings Energy Technology Transfer (BETT) Program to evaluate the energy conservation potential in the food preparation portion of a restaurant's total energy costs. The Restaurant Sector wished to investigate methods of reducing the energy costs in this major segment of restaurant energy usage through the proper choice and application of food preparation equipment. A 10 to 20% reduction in this portion of a restaurant's energy costs would represent substantial savings to restaurant management.

Expertise from the Department of Mechanical Engineering and the Department of Foods and Nutrition at the University of Manitoba were used in the preparation of this report. This cooperative effort has resulted in a comprehensive report which encompasses both the technological aspects of cooking equipment and the more practical aspects of food preparation.

Equipment data was obtained at the National Restaurant Association exhibition held in Chicago during May, 1982 and at HostEx exhibitions sponsored by the Canadian Restaurant and Foodservices Association held in Toronto in April, 1983 and 1984. These exhibitions also provided contact with companies, research groups, colleges, universities and government agencies involved in energy conservation research.

A preliminary version of this report was submitted to Energy, Mines and Resources Canada (EMR) in August, 1983. At the same time, a thorough external review of the report was done by individuals working in the areas of energy conservation, foods and nutrition and engineering. The reviewers comments have been incorporated into the final version of the report. The Restaurant Sector would like to thank the following people for reviewing this document:

R. C. Boivin, Energy Communications Officer, Manitoba Hydro

Bettie Cozzie Ferlin, Food Service Administrator, Pacific Gas and Electric Company

Robert L. Himmel, Projects Manager, Appliance Improvements Research & Development, American Gas Association Laboratories

Denyse LeBlanc, Energy Engineer, Agriculture Canada

Gordon MacKendrick, Group Manager, Government and Marketing Services, Canadian Gas Association

Vera Moroz, Professor of Foods and Nutrition, University of Manitoba

Lynn Stewart, Food Consultant, Agriculture Canada

As recommended, the information in this report has formed the basis for a seminar module on energy efficient food preparation equipment, processes and procedures in restaurants. The module is part of a total seminar package on energy conservation which the Restaurant Sector is preparing for restaurant operators and employees. Portions of this report were used in the restaurant energy conservation manual titled, "Profit by Conserving Energy in Your Restaurant", prepared by the Restaurant Sector and published by EMR in April, 1984. The report is a valuable reference document for community colleges and universities with courses in foodservice and hospitality.

The objective of this study was to evaluate the energy conservation potential of food preparation equipment, processes and procedures. The results of this investigation would be used as a basis for technology transfer to the restaurant sector, in the form of a comprehensive section in the restaurant manual titled, "Profit by Conserving Energy in Your Restaurant" and a future workshop hard copy module.

Food preparation represents about 40% of a restaurant's total energy costs (Figure 3.1).(1) A 10 to 20% saving in this cost would represent a substantial saving to restaurant management. This report addresses the high energy cost associated with food preparation equipment, processes and procedures and describes methods of reducing this cost through the proper choice and application of equipment.

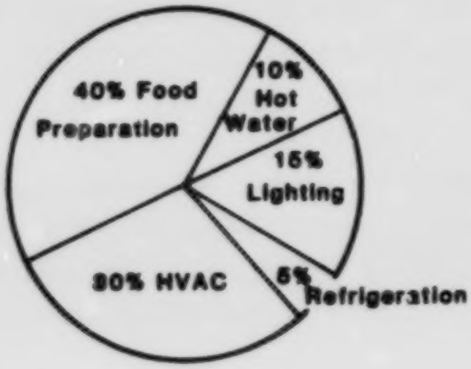


Figure 3.1 Restaurant Energy Costs(1)

Many types and models of food preparation equipment are available. This report explains the factors which should be considered in the purchase and use of equipment to obtain good quality food products using as little energy as possible.

Restaurant Sector personnel attended several hospitality industry exhibitions where current equipment information was obtained from manufacturers' representatives. This information was used along with information obtained from research journals, trade magazines, standard reference texts, restaurant associations, universities and research facilities. The report includes an extensive annotated bibliography of the information obtained. An important reference for anyone involved in restaurant energy management is the text "Energy Management in Foodservice" by Unklesbay and Unklesbay. This book presents a comprehensive approach to energy management in foodservice facilities.

This report has six major divisions. The first division gives a description of the basic mechanisms of heat transfer. The next division evaluates the various types of equipment involved in food preparation.

The second division is subdivided into the major types of equipment: ovens, ranges, griddles, deep fryers, broilers, steam equipment, food processing equipment, clean-up equipment and cold storage equipment. Each type of equipment is evaluated with respect to the principles of operation, the energy saving features available, the relative energy consumption of different designs and the application of the equipment to cooking processes.

The third division discusses the energy saving claims found in manufacturers' brochures. Such claims are often difficult to interpret because of the different types of comparisons that are made. The three main components of a comparison are:

1) the description of the particular pieces of equipment being compared,
2) the basis of comparison and
3) the conclusions drawn from the comparison.

These components are discussed and illustrated with specific examples from manufacturers' brochures.

The processes and procedures used in preparing food influences the taste, texture and appearance of the finished product as well as the amount of energy consumed by the equipment used. Nine cooking methods are described in the fourth division and the pieces of equipment which can be used for each method are given. A comprehensive application guide follows in the fifth division. This table lists the cooking methods applicable to different food products, as well as the type of equipment which will produce a good quality product, while consuming the least energy.

The success of any energy conservation program depends on employee involvement. Therefore, the last division discusses how to implement the ideas presented in the previous divisions. Emphasis is placed on the introduction and maintenance of such a program and the methods used for training employees in energy management.

The information contained in this report will provide restaurant management with valuable information for making knowledgeable decisions about food preparation equipment, processes and procedures.

4.1 Introduction

The art of cooking requires the delicate application of heat to food, therefore, the principles of heat transfer apply and must be understood. Heat is transferred from a heat source to the food by the basic modes of heat transfer: conduction, convection, radiation or a combination of two or three modes.

4.2 Conduction

Conduction is the transfer of heat from one particle of matter to another, usually by molecular collisions. This occurs in all phases of matter, although more readily in solids than in liquids or gases because solids are denser and the molecules are closer together.(2) During cooking, heat is transferred from the outside to the inside of a food by conduction.

4.3 Convection

Convection is the transfer of heat involving the motion of a fluid. It consists of the conduction of heat to or from the fluid and the movement of the heated fluid itself. Since these are inseparable, this report refers to the entire process as convection.(3) Convection occurs naturally due to motion caused by buoyancy forces, which result from changes in density due to the heating of the fluids. Convection also occurs through the use of a fan, which forces a warmed fluid to a new location. These are called natural and forced convection, respectively.

4.4 Radiation

Radiation heating is the transfer of heat by electromagnetic waves. The waves are emitted by an object and are passed to another object where they are reconverted to thermal energy. The net heat transfer between the surfaces is a function of their geometry, the emissivities of the surfaces and the 4th power of their temperatures.(2) When an object appears to be red or white hot it is in the visible part of the electromagnetic wave spectrum. However, at lower temperatures a large portion of energy is transmitted in the form of infrared rays, which have wavelengths too long to be detected by the human eye.

4.5 A Simple Example of Conduction, Convection and Radiation Heating

To better understand the principles of conduction, convection and radiation, consider how they apply to a person in a room sitting in front of a fireplace. The embers, flame and bricks surrounding the fireplace are hot. Heat is transmitted through the brick work by conduction. The portion of the person exposed directly to the fireplace will feel warm, although the remainder of the person's body and the air in the room may be cool; heat is being transferred directly from the flames by radiation. The exposed portions of the person's body are absorbing the short electromagnetic waves given off by the fire and its surroundings. The room may be heated by natural convection: the air close to the fire rises as it is heated while cooler air flows into the void, creating air circulation throughout the room.

Heat transfer in cooking takes place through one or a combination of these methods. The mode of heat transfer used in a piece of cooking equipment depends on the design and construction of the unit.

5.1 Introduction to Ovens

An oven is a fully enclosed, insulated chamber used for baking, roasting and heating foods(4). Ovens are said to cook with 'dry heat' since moisture is not added to the air in the cooking cavity. Three main types of ovens are analyzed in this section: conventional, convection and microwave.

A conventional oven does not use mechanical devices for air movement in the cooking cavity. Air movement still takes place, but the heat transfer is by natural convection and radiation.

Convection ovens improve upon natural convection by mechanically forcing the warmed air through the cavity.(5) Some literature refers to this type of oven as a forced convection or mechanical oven, but the most common name is, simply, convection oven.

Microwave ovens expose food to high frequency electromagnetic waves.(4) Heat transfer from the wave generator to the food is by radiation.

5.2 Conventional Ovens

5.2.1 Introduction

Conventional ovens have an enclosed cavity containing hot air, which is circulated by natural convection. Food placed in this cavity absorbs heat from the surrounding air by natural convection,(3) from the hot interior surfaces of the oven by radiation and from the cooking utensil by conduction. Conventional ovens can be heated by electric elements or gas burners.

5.2.2 Conventional Electric Ovens

Commercial electric ovens are similar to those found in most homes. In domestic electric ovens electric elements heat the surrounding air by natural convection. The heat in the air is absorbed by the food directly or by the cooking utensil which heats the food by conduction. In addition, two-thirds to three-fourths of the heating which takes place in a domestic oven is due to radiation.(6) This radiant heat goes directly to the food or to the cooking utensil and then into the food by conduction (Figure 5.1).

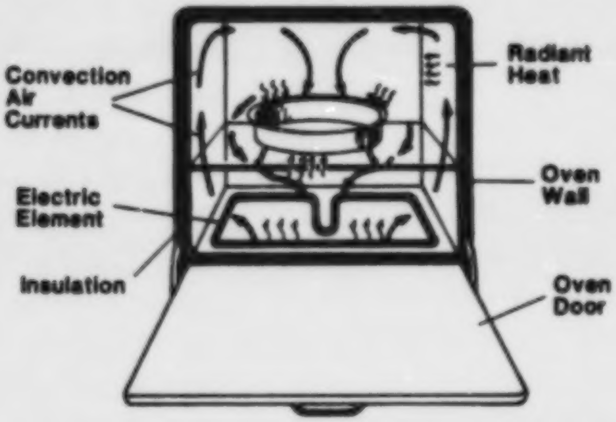

Convection
Air
Currents
Radiant
Heat
Oven
Wall
Electric
Element
Insulation
Oven
Door

Figure 5.1 Domestic Electric Oven

The primary difference between commercial and domestic ovens is their physical construction. Domestic ovens are heated by electric elements located in view on the bottom and top of the cooking cavity. Electric commercial ovens use similar elements but they are located below the bottom deck and above the top deck to make cleaning easier (Figure 5.2).

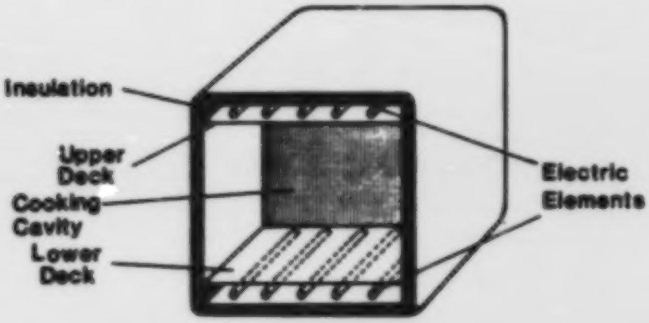

Insulation
Upper
Deck
Cooking
Cavity
Lower
Deck
Electric
Elements

Figure 5.2 Commercial Electric Oven

The decks in commercial ovens complicate the heat transfer from the elements to the food. The heat must be transferred from the elements to the deck by natural convection and radiation. The heat is then transferred from the decks and the walls by natural convection and radiation to cook the food, as in domestic ovens. If food is placed directly on the lower deck, heat transfer takes place by conduction.

The difference in construction between commercial and domestic ovens affects both the operation and energy consumption of the ovens. The warm-up time, that is, the time for each component of the oven to reach the desired operating temperature, ranges from 40 to 60 min for commercial ovens(7) and 3 to 8 min for domestic ovens.(8) Once equilibrium is reached in a commercial oven there is little fluctuation in the oven cavity temperature because of the increased heat capacity provided by the oven deck and walls. Commercial ovens are well insulated to reduce the heat lost from these components to the surroundings.

5.2.3 Convential Gas-Fired Ovens

Conventional gas-fired ovens used comercially are fired indirectly or directly.

Indirect-fired ovens have gas burners located below the bottom deck (Figure 5.3). The hot gases produced by the burners heat the bottom, sides and top of the oven by conduction and natural convection without entering the cooking cavity. The heat is transferred from the interior surfaces of the oven to the food by natural convection and radiation. The hot combustion products flow continuously by natural convection, out the flue at the top of the oven.

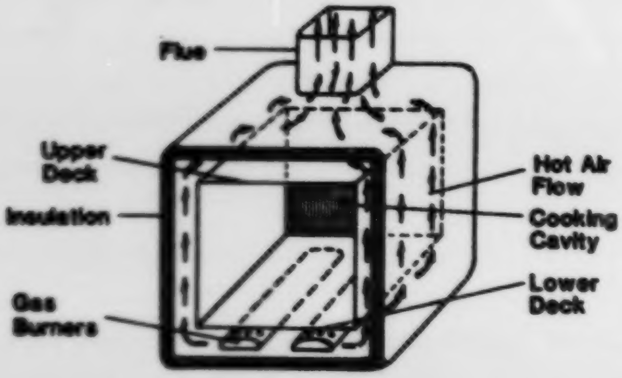

Flue
Upper Deck
Insulation
Gas Burners
Hot Air Flow
Cooking Cavity
Lower Deck

Figure 5.3 Indirect Gas-Fired Oven

Direct gas-fired ovens also have burners located below the lower deck. However, the hot combustion products are directed through the cooking cavity rather than around the cavity as in indirect-fired units (Figure 5.4). The heat transfers directly from the hot gases to the food, mainly by natural convection. This direct heat transfer eliminates the need for preheating the oven.

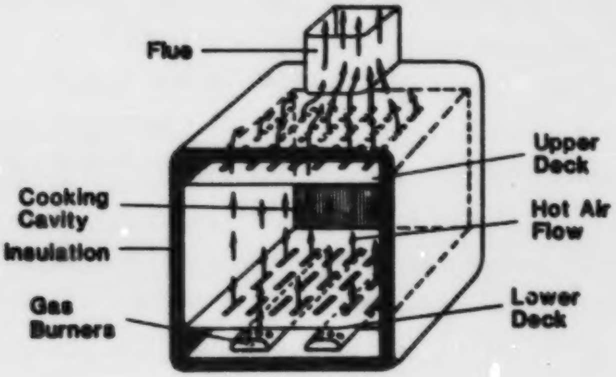

Flue
Upper Deck
Cooking Cavity
Hot Air Flow
Insulation
Gas Burners
Lower Deck

Figure 5.4 Direct Gas-Fired Oven

5.2.4 Energy Consumption of Convential Ovens

Energy-Saving Features

Conventional ovens are now better insulated and, therefore, more energy efficient. Better insulation decreases the amount of heat transferred from the inside to the outside of the oven, reducing the amount of energy required to maintain the cooking temperature and the amount of cooling required in the kitchen.(9)

Gas-fired conventional ovens equipped with electric ignition devices allow gas to be consumed only when the oven is in operation rather than 24 h per day. The average pilot light on a gas-fired oven consumes 5 000 to 7 000 Btu/day, whether or not the oven is used.(10) The savings possible with electric ignition systems depend on the amount of time the oven is used. Restaurants which use their oven intermittently will benefit more than restaurants which use their oven almost continuously.

Energy Comparison

All three types of conventional ovens lose heat by conduction through the oven walls to the surroundings. In addition, heat is lost through the venting of excess moisture and smoke. Both direct- and indirect-fired gas ovens lose energy due to the exhausting of hot gases out the flue. Flue losses represent 60 to 80% of the energy used by a gas-fired oven.(11) Electric ovens do not have this additional loss, therefore, they are more energy efficient than gas ovens. However, the electric oven is not necessarily the least expensive to operate.

To compare operating costs of gas and electric equipment, the cost of cooking a common product in each oven must be calculated. Energy consumption is most accurately determined by metering the electricity or gas used while the product is cooking; the cost can then be calculated from local utility rates. Because watt hour and gas meters are not readily available to restaurant owners, this technique is best suited to laboratory testing.

A simple technique, developed at the University of Houston, estimates the kilowatt hour consumption of electrical foodservice equipment by measuring the "on" time of the thermostat signal light.(12) Unfortunately, a similar technique has not been developed for monitoring gas equipment. Research in this area is required to allow restaurant owners to make valid comparisons between electric and gas-fired equipment.

5.2.5 Application of Conventional Ovens

Conventional ovens are used to bake or roast a variety of foods including meat, poultry, fish, vegetables, baked goods and casseroles. They also are used to reconstitute frozen foods.

The 'dry heat' used in oven cooking results in distinct flavor and texture characteristics in products such as roast meat and baked bread. The surface of bread dough becomes dry and crisp at the end of the baking period giving bread its typical crisp crust. In addition, at temperatures above 160°C (320°F) a complex is formed between the aldehyde groups of reducing sugars and the amino groups of proteins (Maillard reaction); this complex is primarily responsible for the characteristic brown color of baked bread.(13) Cooking meat in the dry air of an oven decomposes one or more of the chemical precursors (e.g. lactones, sulfur-containing compounds) in the lean of meat resulting in the characteristic taste and aroma associated with cooked meat.(14)

Oven cooking consumes more energy than using other pieces of equipment,(15, 16, 17) but is the preferred method of cooking some foods. Therefore, appropriate operating procedures are needed to make oven cooking more energy efficient. Recent research(18, 19, 20) has indicated that energy savings of up to 33% can be achieved in domestic ovens by cold-start cooking (not preheating the oven). Similar savings may be possible with commercial electric and indirect gas-fired ovens. However, caution must be used when extrapolating the energy savings of cold-start cooking in domestic ovens to the savings possible in commercial ovens because of the longer preheating times required in commercial ovens. In addition, product quality in commercial ovens may be adversely affected due to the long period at low temeratures experienced during the preheating portion of cold-start cooking. Cold-start cooking in direct gas-fired ovens would not save energy because preheating in these ovens is virtually unnecessary.

The additional insulation in commercial conventional ovens reduces heat loss so that the oven can be turned off 5 to 10 min before the end of the cooking time, allowing the product to finish cooking in the residual heat of the oven.

Some additional ways to save energy when using a conventional oven include:

- Checking thermostat accuracy and recalibrating, if necessary.
  Reason: If the oven cavity reaches a temperature higher than that preset by the cook, the energy required for preheating will be greater. In addition, the heat transfer rate through the oven walls to the surroundings will increase because of the greater temperature differential.

- Setting the thermostat at the temperature desired when preheating the oven.
  Reason: The oven will not preheat any faster at a higher temperature but there is a possibility of overheating the oven. This

extra energy is wasted because the oven must be cooled down before the food is placed in the oven.

- Filling ovens to capacity by choosing the smallest oven possible to do the job and by scheduling baking and roasting.
  Reason: The heat lost from an oven depends upon the oven's construction and how the oven is used, not on the amount of food being heated. Therefore, to reduce the amount of energy used per kilogram of food, the oven must be loaded to capacity.(21)

- Opening the oven door only when necessary during cooking and relying on timers as much as possible.
  Reason: Each second the door is open the oven loses 1% of its heat, resulting in longer cooking times and additional energy usage to raise the oven temperature again.(22)

- Using meat thermometers with external oven dials to permit the monitoring of meat 'doneness' without opening the oven door.
  Reason: Same as above.

- Using the residual heat in an oven to complete the cooking process or to warm up food that doesn't need to be cooked.
  Reason: This procedure makes use of residual heat that would otherwise be lost.(23)

- Keeping ovens clean.
  Reason: Carbon deposits on the oven door seal can prevent the door from closing tightly, allowing heat to escape to the surroundings. Carbon

deposits on the heating element of a conventional oven act as an insulating layer, inhibiting efficient heat transfer to the air.(24)

- Cooking meat slowly at low temperatures.
  Reason: Cooking a roast 5 h at 120°C (250°F) will save 25 to 50% of the energy that would be required to cook the meat 3 h at 180°C (350°F)(25). Lower temperatures mean that the heat transfer rate through the walls to the surroundings will decrease because of the reduced temperature differential.

- Not wrapping potatoes and other food products in aluminum foil.
  Reason: The foil insulates the food, inhibiting efficient heat transfer.(26, 27)

- Maintain at least a 5 cm (2 in.) clearance between food items and the walls of the oven or solid oven racks or pans.(21)
  Reason: Because a conventional oven relys primarily on natural convection to transfer heat to the food, air must be free to flow around the food.

Techniques for introducing these energy-saving methods to kitchen staff, particularly chefs, are discussed in Section 18, Human Resource Implementation.

5.3 Convection Ovens

5.3.1 Introduction

The convection oven began as a modified conventional oven and was developed to overcome the problem of uneven temperature distribution in the cooking cavity. Air tends to distribute itself into hot and cold layers or zones. These layers are undesirable because food cooks at different rates depending on where it is placed in the oven.(28) The initial solution to this problem was to place a fan in the oven cavity to move the heated air in a turbulence that made it possible to place food anywhere in the cavity and have it cook more evenly.(29)

In recent years it has been found that moving air also improves the heat transfer and overall efficiency of ovens. The fan used in a convection oven circulates air through the cooking cavity resulting in forced convective heat transfer. Air moving over the food reduces the thickness of the insulating layer of air which surrounds the product. This allows more of the available heat to be absorbed so that lower cooking temperatures or shorter cooking times are required. The air can be heated by either electricity or gas.

5.3.2 Electric Convection Ovens

Electric convection ovens use resistance elements to heat the incoming air. The air passes over the elements, absorbing the heat by convection. The heated air is moved into the cooking cavity by a fan, where the heat is transferred to the food by forced convection (Figure 5.5).

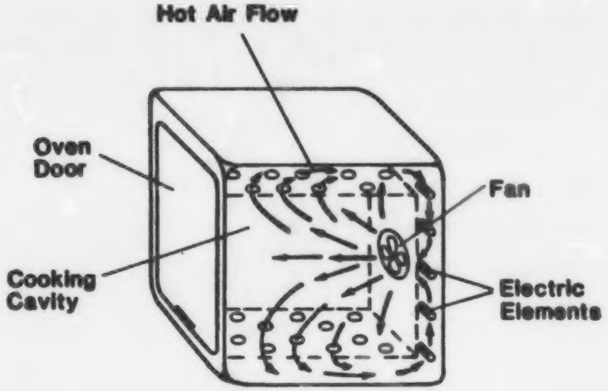

Hot Air Flow
Oven Door
Fan
Cooking Cavity
Electric Elements

Figure 5.5 Electric Forced Convection Oven (Top View)

After passing over the food the air leaves through holes in the side of the cooking cavity. Most of this air returns to the heating elements while a small portion is vented. The vented air is replaced by fresh air which is drawn in near the elements. Venting removes moisture, vapors and other natural by-products of cooking from the cooking cavity.

5.3.3 Gas-Fired Convection Ovens

Gas-fired convection ovens, like conventional ovens, are fired either indirectly or directly.

Indirect gas-fired convection ovens use a system which extracts heat from the burner combustion products and transfers it to fresh incoming air. This air is then blown into the cooking cavity and the products of combustion are vented without coming into contact with the food.

Early indirect gas-fired convection ovens used a double wall to keep the combustion products out of the cooking cavity. The hot burner products flowed between the two walls and heat was transferred from the inside wall to the cooking cavity by forced convection (Figure 5.6). This was a modification of the conventional indirect gas-fired oven and has been succeeded by other designs.

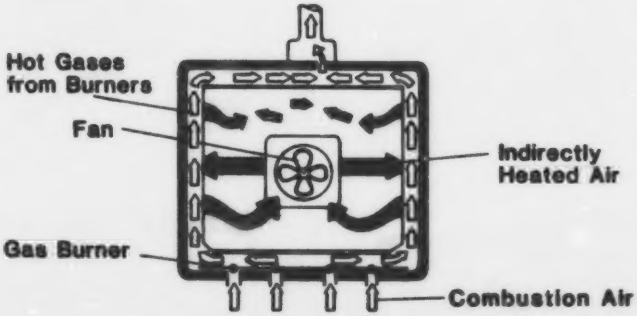


Figure 5.6 Indirect Gas-Fired Convection Oven

A more recent design uses heat exchangers in the form of gas burners enclosed in metal tubes. The burners heat the tubes from the inside while fresh air passing over the tubes transfers the heat into the cooking cavity. Because air flows around all sides of the tubes more heat can be extracted from the products of combustion before they are vented.

Direct gas-fired convection ovens use the hot gases produced by a burner to heat the food directly. A fan blows the products of combustion into the cooking cavity where the heat is transferred to the food mainly by forced convection. The gases are then vented while they are still hot (Figure 5.7).

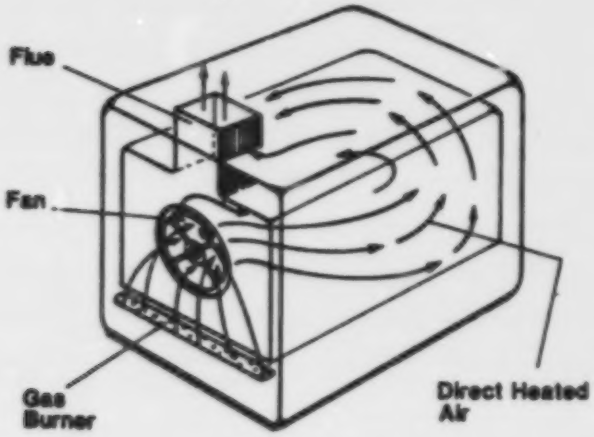


Figure 5.7 Direct Gas-Fired Convection Oven

5.3.4 Energy Consumption of Convection Ovens

Energy-Saving Features

To reduce the amount of energy wasted by venting the hot air, manufacturers of gas convection ovens have incorporated into the ovens, systems which recirculate the air passing through the cooking cavity. Because an electric convection oven reuses the warm air after it passes over the food, energy is conserved.

Two types of recirculation systems are currently available. One uses a specially designed fan and the other uses a recycling tube. Both systems reuse the air which would normally be vented. Hot combustion products from the gas burners are directed around the outside of the cooking cavity walls, as in an indirect gas-fired convection oven. The hot gases are recirculated through the cooking cavity and then vented. Therefore, recirculating ovens are both direct and indirect fired, resulting in more heat being extracted from the burner gases.

The recycling fan system draws air from two sources and exhausts it to one location (Figure 5.8).

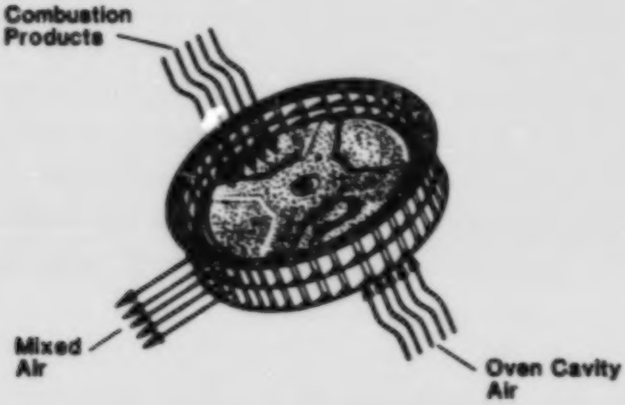

Combustion Products
Mixed Air
Oven Cavity Air

Figure 5.8 Convection Oven Recycling Fan

One source contains indirectly heated oven cavity air and the other contains the air which would normally be vented (combustion products). The fan mixes the two types of air and the resulting mixture is blown into the cooking cavity through the center of the fan (Figure 5.9).

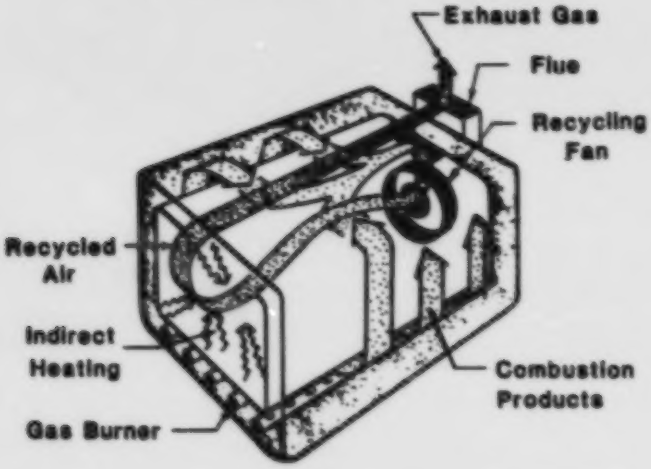

Exhaust Gas
Flue
Recycling Fan
Recycled Air
Indirect Heating
Combustion Products
Gas Burner

Figure 5.9 Convection Oven with Recycling Fan System

A recycling tube performs the same function as a recycling fan but in a different manner. The air enters the oven, passes over heat exchangers located along each side of the oven and is heated indirectly by the burner-produced gases. This air enters the cooking cavity through holes in the sides of the oven, passes over the food and is exhausted. At the same time, some of the hot combustion products leaving the heat exchanger, which would normally be vented, are pulled through a recycling tube and into the cooking cavity.(30) This provides direct heat for cooking (Figure 5.10).

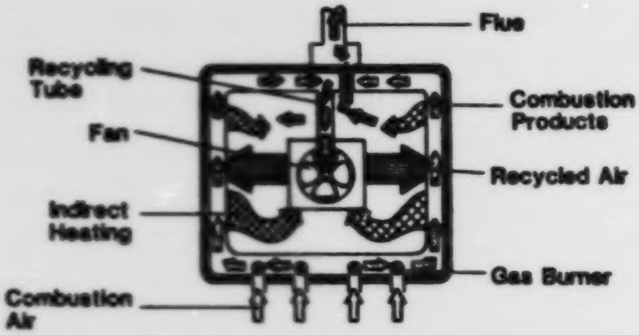


Figure 5.10 Convection Oven with Recycling Tube

Different types of air circulation systems are applied to electric and gas-fired convection ovens. Turbulence or free flow ovens use a fan to move the air, creating eddies or swirls. In this type of oven, the size and placement of the product being cooked affects the flow of air (Figure 5.11). Because the amount of heat transferred through forced convection depends on the air flow rate as well as the relative temperature, changes in flow also change the efficiency of the oven.

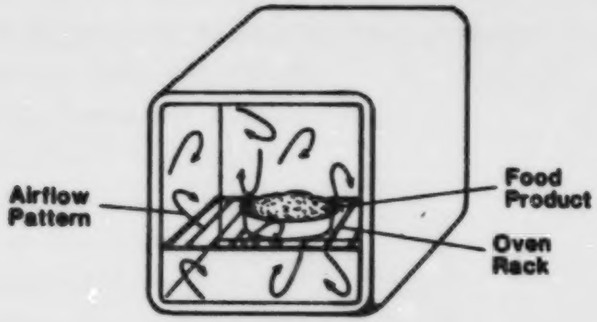

Airflow Pattern
Food Product
Oven Rack

Figure 5.11 Convection Oven with Turbulent Airflow

More recently constructed forced convection ovens use a controlled system of airflow. Instead of entering the cooking cavity at one location, the hot air enters through vents in the oven walls and exits at the rear of the cavity. This creates a definite flow pattern which provides even heat transfer regardless of the position of the food in the oven (Figure 5.12).

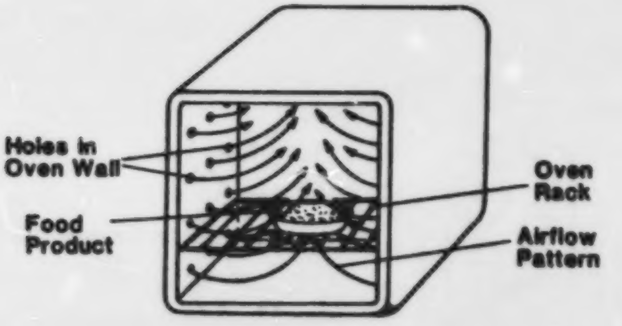

Holes in Oven Wall
Food Product
Oven Rack
Airflow Pattern

Figure 5.12 Convection Oven with Controlled Airflow System

Energy Comparison

Most of the heated air in an electric convection oven is recycled, therefore, little energy is wasted. A gas-fired convection oven with a recycling feature is the next most efficient. Although considerable energy is still wasted, convection ovens with recycling features offer up to 40%(31,32) better heat transfer efficiency than ovens which vent the heated air after it has passed through the cooking cavity once.

In some areas of Canada, gas-fired convection ovens may be less expensive to operate than electric convection ovens. To determine which oven has the lower operating cost the restaurant owner must compare the energy consumption of each unit and the local cost of gas and electricity.

5.3.5 Application of Convection Ovens

Convection ovens are used for baking, roasting, rapid reheating of previously prepared foods and fast defrosting and heating of frozen foods.

The temperatures used in conventional oven cooking may be reduced by approximately 25°C (50°F) when using a convection oven because heat is transferred at a faster rate by forced convection than by natural convection. It is important that convection ovens be loaded so that air is free to flow around the food items. Blocking the movement of air in the oven defeats the purpose of forced air flow.(23)

Convection ovens perform the same cooking functions as conventional ovens and produce products of equivalent quality. The restaurant owner should be encouraged to purchase a convection oven because it is more energy efficient than a conventional oven.

Cold-start cooking in convection ovens has been shown to result in energy savings of up to 14%(33). The other energy-saving tips described in the previous section on conventional ovens are also applicable to convection oven cooking.

5.4 Microwave Ovens

A microwave is a very short electromagnetic wave with a wavelength between that of common radio waves and light waves. Microwave ovens use a magnetron to produce waves of a single wavelength and a frequency of either 915 or 2450 MHz (megahertz).(34) The waves are directed into the oven cavity by a wave guide where they reflect off the interior surfaces of the oven cavity until they contact the food (Figure 5.13).

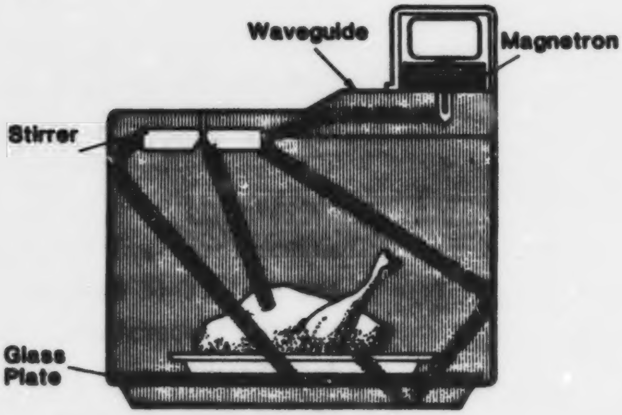


Figure 5.13 Microwave Oven Operation

Since microwaves are sinusoidal, a rapid reversal of charge is constantly taking place in the electromagnetic field they generate. When microwaves penetrate food, the dipolar molecules in the food oscillate about their axes in response to the reversal of charge. Heat is generated in the food as a result of this rapid oscillation.(35) This is a form of radiation heat transfer and is the primary cause of cooking in microwave ovens. Microwaves penetrate food to varying depths depending on the moisture content and density of the food. The 915 MHz wave loses half its strength in 7.6 cm (3 in.) of water and 0.8 cm (0.3 in.) of steak, while the 2450 MHz wave loses half its strength in 1.3 cm (0.5 in.) of water and 0.25 cm (0.1 in.) of steak. The 2450 MHz wave will penetrate to about 3.8 cm (1.5 in.) maximum in beef.(36) Heat transfer to the center of the food takes place by conduction.

The specific heat and dielectric properties of food effect the rate of cooking and heating in a microwave oven. Specific heat is the amount of heat required to raise the temperature of a unit mass of a product by 1°.(37) Dielectric properties determine how well a substance absorbs microwaves. The dielectric constant is used to express the dielectric properties mathematically. The higher the numerical value of the dielectric constant the faster a food reaches serving temperature. The dielectric constant of a food increases as the moisture content and density of the food increase.(38)

All microwave ovens currently produced have the same basic design: a wave generator and a cooking cavity. The primary differences between models are:

1) the door seals,
2) the power input into the generator, and
3) the method of directing the waves into the cooking cavity.

The door of a microwave oven requires careful design. It provides access to the cavity and also prevents the waves from escaping into the surrounding area. Door tightness is usually achieved by good metal to metal contact combined with safety interlocks to prevent the oven from functioning if the door is not tightly closed. Another way of sealing the waves in the oven is to use a choke seal with an energy absorbing material. A typical choke seal is an aluminum channel which traps and dissipates waves (Figure 5.14). The energy-absorbing material stops microwaves which may get past the choke.

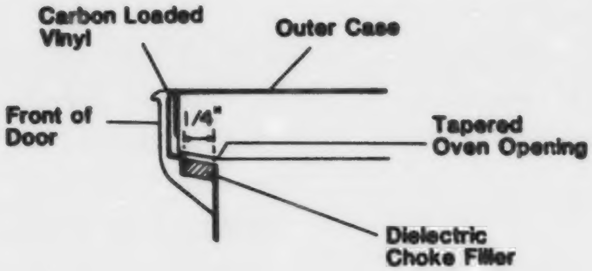

Carbon Loaded Vinyl
Outer Case
Front of Door
1/4"
Tapered Oven Opening
Dielectric Choke Filler

Figure 5.14 Cross Section of Oven Cavity and Inner Door Showing a Choke Seal

The power input into microwave ovens varies from about 400 to 6000 W.(39) Most ovens operate at about 45% efficiency,(40) therefore actual outputs range from about 200 to 3000 W. The power input is an important factor when purchasing a microwave oven because it effects cooking times. For example, an oven with an input of 400 W requires about 26 min/kg (12 min/lb) to cook chicken while one with an input of 3000 W would require about 3.3 min/kg (1.5 min/lb).(41) To allow time for heat transfer to the center of the food to take place by conduction, many of the more powerful units have a feature which turns the power on and off at definite intervals to provide even cooking

Most microwave ovens now produced have a method of stirring or scattering the waves as they enter the cooking cavity. This is necessary as microwaves move in fixed paths until an obstacle is encountered. Early models without wave-stirring devices tended to have hot spots which resulted in uneven cooking. Some microwave ovens use a rotating slotted disc or similar device to vary the wave paths. Other models use a turntable which rotates the food in the oven cavity.

5.4.1 Energy Consumption of Microwave Ovens

Energy-Saving Features

Many models of microwave ovens are available, however, they all have approximately the same energy efficiency. The only energy lost is in the conversion of electricity to radiation and is the same regardless of the mechanical construction of the oven. Using microwave ovens decreases the rate of heat transfer to the surroundings because heat is generated in the food itself; heat is not transferred from hot air in the oven cavity. The only heat in the oven cavity is that given off by the food as it cooks. The energy efficiency of microwave ovens is high; thus, manufacturers focus their research on developing methods to improve the quality of microwave-cooked food.

5.4.2 Application of Microwave Ovens

The microwave oven is used to thaw, heat and cook foods. The time required to perform these operations depends on several factors:(42)

1) Oven wattage - higher wattage means faster cooking times.
2) Initial temperature of the food - the higher the initial temperature, the shorter the cooking time.
3) Mass of the food - the greater the mass, the longer the cooking time.
4) Density of the food - denser foods take longer to cook than porous ones.
5) Load size - the larger the load, the longer the total cooking time.
6) Shape of the food - regular shapes cook more uniformly than irregular ones.

The shape of the container holding the food also affects the cooking time. The ideal container is: round with sides that angle inward toward the bottom, concave at the base, smoothly shaped without sharp corners, suitable for low and high temperatures and absorbs very low levels of microwave radiation.(43)

Cooking times are considerably shorter in the microwave oven than with conventional cooking methods.(44,45) In general, because of the shorter cooking times possible with microwave cooking, foods retain more of the heat labile vitamins such as thiamine and ascorbic acid. The smaller quantity of water required for cooking vegetables in the microwave oven also reduces water soluble vitamin losses.(46,47)

Although microwave ovens have distinct advantages in terms of cooking time and vitamin retention, the quality of some products cooked in a microwave oven is less than acceptable.(48) Large pieces of meat cook unevenly because microwaves penetrate the meat to limited depths. Stewing chickens and less tender cuts of meat remain tough after cooking because cooking times in the microwave are too short for any tenderizing effects to occur. The Maillard reaction does not occur because no exterior heat is applied, therefore yeast bread and biscuits baked in a microwave oven do not have their characteristic brown crusts.(13) Eggs cooked in the shell may explode because of the rapid pressure buildup inside the egg.

The number of microwaves entering the cooking cavity of a microwave oven is constant regardless of the size of the oven load. Several studies(49,50) have shown that as the quantity of food is increased, the total cooking time in a microwave oven increases; in a conventional oven the cooking time is not affected by oven load. Therefore, unlike conventional and convection ovens, cooking large quantities of food in a microwave oven is a disadvantage. The resulting increase in cooking time in a microwave oven depends on the type of food being cooked as well as the factors previously discussed.

Microwave ovens are useful for sandwich shops and similar operations because, on a single-serving basis, ovens are faster than other equipment for heating foods. Microwave ovens also allow a restaurant owner to expand the menu and reduce risk of wastage by keeping slower-selling menu items frozen and reconstituting them when they are ordered. By using microwave ovens to reheat food for late-dining customers, large-volume operations can extend their serving hours without increasing overhead.(51)

5.5 Energy Comparison of Conventional Convection and Microwave Ovens

Microwave ovens are the most energy-efficient ovens currently available. During microwave cooking heat is generated in the food itself; the oven cavity and container holding the food are not directly heated.(35) The energy dissipated in the conversion of electricity to electromagnetic waves is the only energy not used to cook the food. The quantity of food which can be cooked in a microwave oven at one time is limited.

Microwave oven efficiencies range from 40 to 45% compared to 10 to 25% for traditional ovens.(41) Although studies comparing microwave and conventional ovens have shown that microwave ovens use significantly less energy to cook the same food,(52,53,54) other research has shown that the energy savings possible with microwave cooking are affected by the quantity of food being cooked and the cooking time. As the amount of food or cooking time increases the energy savings decrease.(49,50) In addition, the quality of some products cooked by microwaves is inferior to that of the same products cooked in other types of ovens. For example, the flavor of beef cooked in a microwave oven is less desirable because a long cooking time in 'dry heat' is needed to develop a full, meaty flavor. For the same reason yeast breads and biscuits do not have the characteristic crisp upper crust when baked in a microwave oven.

Both conventional and convection ovens produce roast meats and baked products of acceptable quality. However, the convection oven has an efficiency of 35% and the traditional oven is only 10 to 25% efficient.(41) Work done at Michigan State University in 1959(55) showed that using a convection oven reduced the cooking time of meat loaf by 38% and energy consumption by 23% when compared to a conventional oven. In a recent study at the University of Nebraska, three pork products were cooked in a forced-convection oven and in a rotary-hearth still-air electric oven. The forced-convection oven used consistently less energy(56)

In summary, factors to consider when selecting an oven are: the desired product quality, the quantity of food being prepared at one time and the relative energy efficiences of the ovens. For cooking small quantities of vegetables, the microwave oven is the best choice because it is the most energy efficient and produces acceptable quality. A large roast, however, should be cooked in a convection oven to achieve a good quality product with the least energy usage.

6.1 Introduction

The range is one of the most versatile items of cooking equipment available for use in a restaurant kitchen. It is particularly useful for restaurants which cook small quantities of a variety of foods. In larger restaurants the range is often used for tasks more efficiently performed with specialty equipment such as steam-jacketed kettles, steamers, griddles or deep fryers.(54) On the other hand, these tasks may not be performed frequently enough to warrant the purchase of specialty equipment. Ranges can be obtained with a griddle surface or broiler and an oven for baking, roasting and holding food.

6.2 Variations of Design

Cooking on a range is done in pots or pans placed on burners or heated plates. The heat is supplied by burning gas or electric resistance elements. Ranges are available in two basic styles, those with a number of individual burners and those with one large heated cast iron or steel plate.

6.2.1 Individual Burners

Ranges equipped with individual burners use either gas or electricity. Gas-fired units have a cast iron or steel framework which supports the pots, above the burners. The burners are traditionally ring-shaped; the air required for combustion enters around and through the center of the ring (Figure 6.1). As the hot combustion products from the burner pass over the bottom of the pot, heat is absorbed by the pot. Thus, heat transfer occurs by convection and, to a small degree, by radiation.

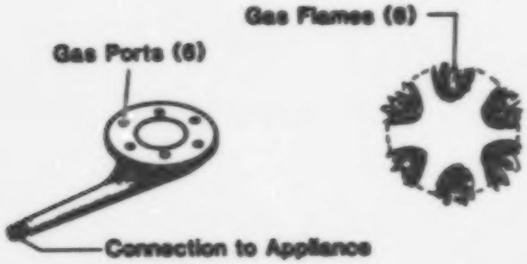


Figure 6.1 Ring Burner and Associated Flame Pattern

Ranges equipped with individual electric burners usually have a sheet steel top with openings for the elements. The elements are coiled metal tubes containing a resistance heating wire embedded in a ceramic-filled core (Figure 6.2).

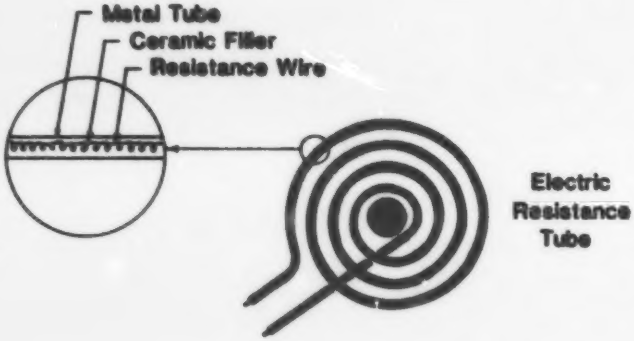


Figure 6.2 Electric Burner Element

Domestic electric ranges use elements with a flat top surface, allowing pots and pans to be placed directly on the elements. Such elements would be damaged by the heavy stock pots used in a commercial application, therefore, restaurants use ranges with a heavy cast iron or steel plate over each element. Heat is transferred from the element to the plate, then to the pot by conduction.

6.2.2 Hot Tops

Ranges with a large steel plate instead of individual burners,for a cooking surface are called 'hot tops', 'boiling plates', or 'uniform heat tops'. Hot tops are generally built so that different sections of the top are at different temperatures. For heavy duty continuous cooking a large range of temperatures can be obtained by changing the position of the pots and pans on the cooking surface. Hot tops are available in both gas-fired and electric models.

Gas-fired hot tops are heated by a number of burners located underneath the steel plate. Heat transfer occurs by convection and, to a small degree, by radiation, as the hot gases from the burners pass over the underside of the plate on the way out the flue. The burners may be ring, star, or tubular in shape and are individually controlled. Since the location of the burners differs from model to model the operating procedures also differ. When there are burners under all parts of the top, operators must decide which sections they wish to be hot and warm. Other hot tops have burners located only under the front area. The exhaust from these burners travels from the front to the rear of the hot top producing a temperature gradient from hot at the front to cooler at the back. It is vital, therefore, that the operator know where the burners are located and how each is controlled.

Electric hot tops are heated by resistance elements clamped to or imbedded in the underside of steel plates (Figure 6.3). Heat is conducted directly from the elements to the steel plates. The elements usually have separate controls which, like the gas-fired hot top, allow the operator to control the temperature of different sections of the surface.

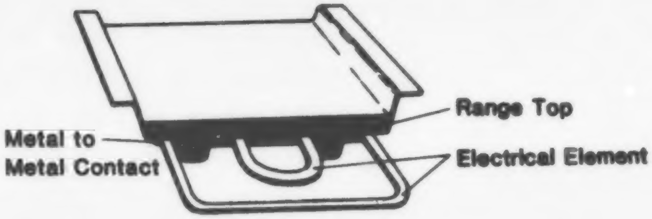

Range Top
Metal to
Metal Contact
Electrical Element

Figure 6.3 Electric Elements Clamped to the Bottom of a Range Top

6.3 Energy Consumption of Ranges

6.3.1 Energy-Saving Features

Electric ignition systems offered by some manufacturers can save a substantial amount of energy compared to pilot light systems. A 1977 study(58) showed that the pilot lights of a natural gas range use from 350 to 675 cu. ft. of gas each 30 days.(56) Electric ignition systems mean that gas is consumed only when the range is in use rather than 24 h per day. The savings possible with electric ignition depend on the amount of time the range is in use. Restaurants which use their ranges only intermittently during the day will benefit more than restaurants which use the range almost continuously.

Traditional ring-shaped burners (Figure 6.1) are being replaced with burners designed to provide more even heating and improved combustion efficiency. With star-shaped burners (Figure 6.4), combustion air enters through the center of the burner and around both sides of the gas ports. This results in more complete combustion of the gas and a more concentrated flame. One manufacturer claims their star-shaped burner is 24% more energy efficient than the traditional ring-shaped burner.(59)

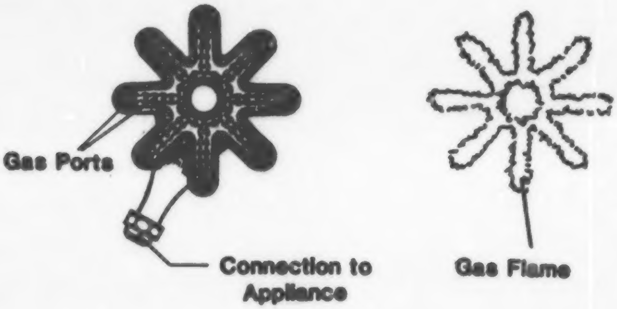


Figure 6.4 Star Burner and Associated Flame Pattern

6.3.2 Energy Comparison

Electric elements convert electricity into heat at essentially 100% efficiency. If the cooking pot is the correct size and has a flat bottom most of this heat is conducted directly to the food. Gas ranges heat by convection and radiation. As the hot gases from the burner pass over the base of the pot, some of the heat is absorbed by the pot but the remainder is lost to the exhaust. Flue losses account for about 50% of the input energy.(60) Therefore, electric ranges are more efficient than gas ranges.

In some areas of Canada gas-fired ranges may be less expensive to operate than electric equipment. To determine which range has the lower operating cost, the restaurant owner must compare the energy consumption of each type of unit and the local cost of gas and electricity.

6.4 Application of Ranges

The range is a multipurpose piece of equipment for quantity food preparation. Steam kettles, steamers, griddles and deep fryers can perform their various functions more effectively than a range, requiring energy. However, ranges are used primarily in small restaurants where the cooking volume does not warrant the purchase of speciality equipment and in restaurants with a large menu selection. Although electric ranges are more energy efficient, cooks often prefer gas-fired ranges because instant temperature changes can be achieved.

The energy consumption of ranges can be reduced by:

- Using cooking utensils made of a good conducting metal such as aluminum.
  Reason: A pot made of a material with a high conductance increases the rate of heat transfer from the heat source to the food.

- Using cooking utensils with flat bottoms.
  Reason: Flat bottoms on the utensils maximize the contact area with the electric element or hot top,(61) resulting in an increase in the amount of heat transferred.

- Using cooking utensils with tight-fitting lids.
  Reason: The lids reduce heat loss from the food due to convection and evaporation.(61)

- Heating only the portion of a hot top range being used.
  Reason: Energy used to heat uncovered portions of the hot top is lost to the surroundings.(62)

- Covering as much of a hot top range as possible with pots.
  Reason: Same as above.(62)

- Adjusting gas burners so the flames do not extend around the sides of the pot.
  Reason: Heat from flames extending around the sides of the pot goes largely to the surroundings rather than to the pot.(61)

- Reducing the heat when food begins to boil, that is maintaining liquids at a simmer, unless a rolling boil is necessary to keep foods from sticking together (e.g. pasta).
  Reason: The temperature of the liquid will not increase beyond its boiling point so the food will not cook any faster. However, the amount of steam produced does increase, therefore, the amount of heat lost to the surroundings also increases.

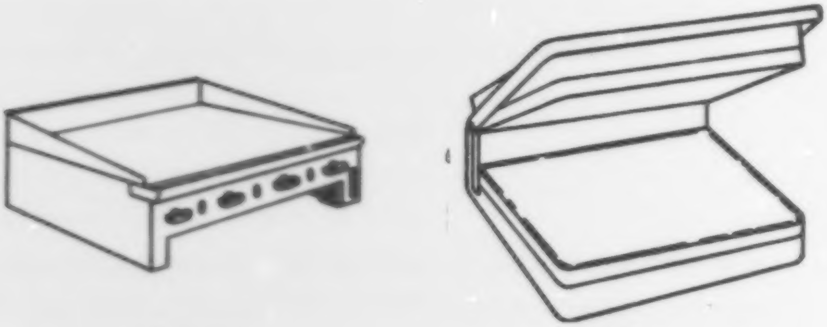
- Turning off an electric range a few minutes before cooking is finished.
  Reason: This allows food to finish cooking with the residual heat of the range rather than losing this heat to the surroundings.

- Removing grease and dirt build-up on the range surface, burner plates or elements daily. Reason: Grease and dirt act as insulators and decrease the amount of heat transferred from the heat source to the cooking utensil.(63)

7.1 Introduction

Griddles are flat metal plates heated from beneath by gas or electricity (Figure 7.1).(64) The food is placed directly on the plate, which may be coated with a film of fat*. A grill is a cooking unit similar to the griddle except that the food is placed between two heated surfaces (Figure 7.1).(64) It should be noted that the terms griddle and grill are often used interchangeably. Because griddles and grills are similar in construction and grills are less common than griddles, the remainder of this section will deal with griddles.

Griddles may be almost any width from 15 cm (6in.) to many feet, and from 0.3 to 1.2 m (1 to 4 ft.) deep, although the most common sizes are 60 to 245 cm (24-96 in.) wide and 45 to 60 cm (18 to 24 in.) deep.(65)



Griddle

Grill

Figure 7.1

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* The 'fat' used on griddles is usually a liquid, 100% vegetable shortening.(66)

7.2 Variations of Design

7.2.1 Electric Griddles

Electrically-heated griddles are similar in construction to electric hot top ranges (Figure 6.3). Both have elements clamped to the bottom of or imbedded in a metal plate. The elements are usually concentrated near the edges of the plate where heat loss is the greatest; this makes the entire surface area usable instead of just the center area. Because the elements are thermostatically controlled it is possible to set the surface temperature between 65 and 230^0C (150 and 450^0F).(67) More than one thermostat is often used to allow different sections of the plate to be kept at different temperatures. Heat is transferred from the elements to the plate by conduction. The food, which is in direct contact with the plate, is cooked by conduction.

7.2.2 Gas-Fired Griddles

Gas-fired griddles have ring-, star-, or rectangular-shaped burners beneath the plate. Burners are usually placed under the entire plate to provide even heating and, in some cases, to allow different temperature settings for different sections of the griddle. The hot gases from the burners pass under the plate and are vented out the back of the griddle. Heat is transferred from the combustion products to the plate mainly by convection and, to a small degree, by radiation.

7.3 Energy Consumption of Griddles

7.3.1 Energy Saving Features

Energy is lost through any part of a griddle cooking surface not covered by food.(62) Electric griddles with multiple thermostats are available; also available are gas units with individual burner controls located under the plate.(68) These features allow the operator to concentrate heat on the section of the griddle being used. However, heat loss still occurs because of conduction to the cooler sections of the plate.

The energy consumption of a gas griddle can be reduced by using an electric ignition system instead of a pilot light.(58) Electric ignitions mean that gas is consumed only when the griddle is in operation, rather than 24 h per day. The savings possible depend on the amount of time the griddle is in use. Restaurants which use their griddle intermittently will benefit more than restaurants which use their griddle almost continuously.

7.3.2 Energy Comparison

Griddles provide an easy-to-use method for frying a variety of foods, but both electric and gas griddles waste energy. Heat is constantly lost through the bottom of the plate and from parts of the cooking surface not covered by food.(62) The long preheating times required to achieve uniform plate temperature consume additional energy. This energy is never recovered because it goes into the surrounding air as the griddle cools down. Gas-fired griddles are less efficient than electric models because a portion of the burner-produced heat is lost when the hot combustion products are vented. Flue losses from griddles are similar to those from hot top ranges which have been measured as 50% of the input energy.(60)

In some areas of Canada gas-fired griddles may be less expensive to operate than electric griddles. To determine which griddle has the lower operating cost the restaurant owner must compare the energy consumption of each type of unit and the local cost of gas and electricity.

7.4 Application of Griddles

The griddle has a wide application for both quantity cooking and short-order food preparation. The main functions of the griddle are:

1) coagulation of protein (e.g. eggs, fish),
2) development of flavor (e.g. browning meat),
3) development of a crisp surface (e.g. potatoes, bacon, pancakes),
4) melting fat in meat (e.g. sausage, bacon, hamburgers), and
5) toasting (e.g. sandwiches, buns).(69)

Some cooks use the griddle not only as a direct cooking surface but as a hot top range to heat food in pots and pans. However, pots scrape the 'tempering' or coating from the surface of the griddle causing foods to stick when the griddle is again used as a cooking surface. Cooking in pots on a griddle is inefficient because any burned-on food residue prevents the pot from making good contact with the griddle surface.(70) Therefore, the griddle should be used only for surface cooking.

Energy consumption when cooking on a griddle can be reduced by:

- Covering the griddle surface as completely as possible with food.
  Reason: The majority of the griddle heat is used productively to cook food rather than being lost to the surroundings.(68)

- Preheating the griddle no longer than recommended by the manufacturer.
  Reason: If the griddle is not used immediately after it reaches the temperature required, then heat which could be used productively to cook food is lost to the surroundings.(68)

- Heating only the portion of the griddle which is being used.
  Reason: Energy used to heat portions of the griddle not covered with food is lost to the surroundings.(62,68)

- Idle the griddle at 100°C (200°F) during slow periods.(1)
  Reason: Less energy will be used to maintain the griddle at this idling temperature then at higher cooking temperatures.

- Checking thermostat accuracy regularly and recalibrating as necessary.
  Reason: If the griddle reaches a temperature higher than the temperature which was preset, the rate of heat transfer to the surroundings will increase because of the greater temperature differential.

- Cleaning the griddle surface of food particles after each use.
  Reason: A shiny surface emits less radiant heat to the surroundings. Food particles on the griddle act as an insulating layer and inhibit efficient heat transfer.(71)

8.1 Introduction

A deep fryer cooks food immersed in heated fat*. Deep fryers consist of four basic parts:

1) a kettle to hold the fat,
2) a metal basket to hold the food,
3) a thermostat to keep the fat temperature constant, and
4) a heat source.

The kettles are usually made of stainless steel because it is easy to clean, durable and non-absorbent. Rectangular-shaped kettles are standard and have sufficient capacity to allow the food to be completely covered with fat, insuring simultaneous cooking of all surfaces. The basket used to lower the food into the fat is usually made of nickel-plated rod or wire and has long, sturdy handles for safe and easy handling. All deep fryers require thermostats accurate to within 5°C (9°F) of the set temperature, over a range of 90 to 200°C (200 to 400°F).(72) If the fryer temperature varies as little as 10°C (15°F) the flavor of the final product may be affected. Because thermostats fail occasionally and the fat may begin to burn if the temperature exceeds 200°C (400°F), fryers are equipped with automatic cut-out mechanisms. In the event of thermostat failure the entire fryer is turned off once the fat temperature exceeds a preset value. Deep fryers are heated by electricity or gas.

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*The 'fat' used for deep frying is a solid or liquid shortening which is either a 100% vegetable product or an animal/vegetable mixture.(66)

8.2 Variations of Design

8.2.1 Electric Deep Fryers

Electric deep fryers have electric resistance elements which are immersed directly in the fat (Figure 8.1).

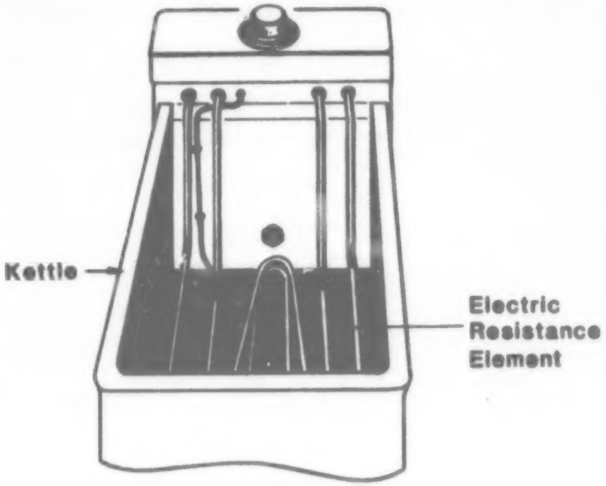

Figure 8.1 Heating System for an Electric Deep Fryer

Heat is transferred from the elements to the fat by conduction. Because the entire element is immersed in the fat all of the heat produced is absorbed by the fat, resulting in an efficiency approaching 100%.

8.2.2 Gas-Fired Deep Fryers

Gas-fired deep fryers use a gas burner to heat the bottom or sides of the kettle instead of heating the fat directly (Figure 8.2). Heat is transferred from the burner to the kettle mainly by convection and to a small degree by radiation, then from the kettle to the fat by conduction and natural convection.

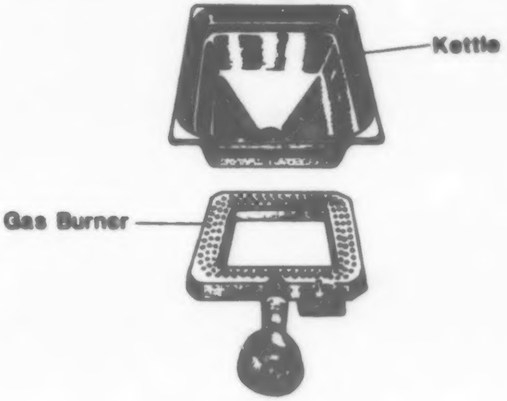

Figure 8.2 Heating System for a Gas-Fired Deep Fryer

The type of gas burner used in deep fryers varies with the manufacturer. The traditional bunsen-burner type is designed to heat all four sides of the kettle at the same time. The entire exterior surface of the kettle is exposed to the hot combustion products before they are vented. Another type of fryer uses an infrared burner to provide a radiant heat source for heating the kettle. In a third type, a number of tubular steel burners set inside metal tubes are immersed in the fat. Heat is transferred from the combustion products to the tubes by convection, then from the tubes to the fat by conduction and natural convection.

Some gas-fired fryers have a 'cold zone' which collects crumbs and sediment from the frying area. These particles become trapped in the cold zone and therefore, do not carbonize or contaminate the fat. This extends the life of the fat and reduces the overall costs of deep frying.(73,74)

8.2.3 Pressure Deep Fryers

Pressure fryers are equipped with tightly-sealed lids which hold steam, under pressure, over the top of the fat.(75) The steam comes from the moisture given off by the food being cooked or it can be injected into the kettle. At the end of the cooking cycle the pressure is automatically released from the kettle through an exhaust system. A locking device on the lid prevents the fryer from being opened until the pressure is released.

Pressure frying increases the rate of heat transfer into the food, reducing the cooking time. The food tumbles in the oil insuring even cooking. Some operators feel that pressure fryers shorten the life of fat and that the time savings are reduced because of the time lost while the pressure is released.(76)

8.3 Energy Consumption of Deep Fryers

8.3.1 Energy-Saving Features

Conventional gas-fired deep fryers are heated by a single gas burner located beneath the vat. The other burner designs described in the previous section (8.2.2) increase the amount of heat transferred from the burner to the kettle and therefore save energy. Manufacturers of infrared gas fryers claim an average efficiency of over 70%.(77)

Regardless of the type of burner gas-fired deep fryers should be equipped with electric ignitions instead of pilot lights.(58) Electric ignitions mean that gas is consumed only when the deep fryer is in operation rather than 24 h per day. The savings possible depend on the amount of time the fryer is in use. Restaurants which use their fryer intermittently will benefit more than restaurants which use their fryer almost continuously.

8.3.2 Energy Comparison

Electric deep fryers are more energy efficient than gas-fired fryers because the electric elements are immersed directly in the fat and almost all of the energy entering the fryer is transferred to the fat. Although recently-designed gas-fired fryers are more effective than the conventional bunsen-burner type of fryer, none are as efficient as the electrically-heated units. All gas-fired fryers waste energy because hot combustion products are vented.

Electric deep fryers are not necessarily more economical to operate than gas-fired fryers. In some areas of Canada, gas-fired fryers may be less expensive to operate than electric fryers. To determine which deep fryer has the lower operating cost, the restaurant owner must compare the energy consumption of each unit and the local cost of gas and electricity.

8.4 Application of Deep Fryers

Deep-fried foods are offered by restaurant owners because they require little advance preparation, cook rapidly and can be 'cooked to order'. Deep fried foods form a large portion of the total food volume of many restaurant operations.

The temperature of fat in deep fryers must be maintained within set limits to insure that food products of acceptable quality are produced. Fat temperatures which are too low require that the food be cooked longer to obtain the desired degree of browning. Therefore, fat absorption is increased, producing a greasy product.(78) Temperatures which are too high burn the exterior of the food and leave the centre uncooked. Therefore, temperature adjustments cannot be used to save energy and other procedures must be used instead.

For restaurants which have peak periods alternating with slow periods, it is more energy efficient to have several small fryers rather than one large fryer. When food production is low some of the fryers can be turned off.(79) Many manufacturers offer split vat fryers. Each half vat operates as an independent fryer, allowing one vat to be turned down or off during slow periods. Restaurants equipped with only one fryer should idle it at 100°C (200°F) during slow periods rather than leaving it at the cooking temperature. The lower idling temperature will save energy and extend the life of the fat.(80) Fryers also should be covered when idling during off peak periods.

Energy consumption of deep frying can be reduced by:

- Preheating with the thermostat set at the frying temperature desired.
  Reason: The fryer will not preheat any faster at a higher temperature, but more heat will be transferred from the hot oil to the surroundings.(80)

- Draining foods well before frying.
  Reason: Large amounts of energy are required to evaporate any excess moisture on the food.(81)

- Thawing foods with long cooking times (e.g. meats) before frying.
  Reason: Cooking times and therefore energy use increase appreciably if the food is fried from the frozen state(82) and the product may burn on the outside while being undercooked in the interior. However, frozen foods with short cooking times (e.g. potatoes) should not be thawed before frying because if thawed they absorb up to 2 1/2 times more fat.

- Being sure the fat completely covers the elements of electric deep fryers.
  Reason: This insures that all of the heat produced by the elements is used to heat the oil and is not lost to the surroundings.

- Loading the frying basket only to the manufacturers stated capacity (1/2 to 3/4 full).
  Reason: Overloading the frying basket causes the temperature of the fat to decrease and therefore, increases the cooking time and energy consumed.(83)

- Cleaning the heating elements of electric deep fryers at least weekly to remove any burned on food. Reason: Food particles which are burned onto the elements act as an insulating layer and inhibit efficient heat transfer from the elements to the oil.(84)

9.1 Introduction

A broiler cooks food, usually meat, by exposing it to a high temperature heat source. It cooks mainly with radiant heat in the form of infrared waves emitted from hot ceramics, charcoal, gas flames or electric elements. Usually broilers cook one side of the food at a time, although there are conveyor broilers which cook both sides at the same time.

The three main designs of a broiler are:
1) horizontal or overfired,
2) char or underfired and
3) specialty broilers.

9.2 Variations of Design

9.2.1 Horizontal or Overfired Broilers

Horizontal broilers use an overhead or top heat source which produces radiant heat in the form of infrared waves that are absorbed by the food. The heat source is located in a cavity, the front of which may be open or equipped with a door (Figure 9.1).

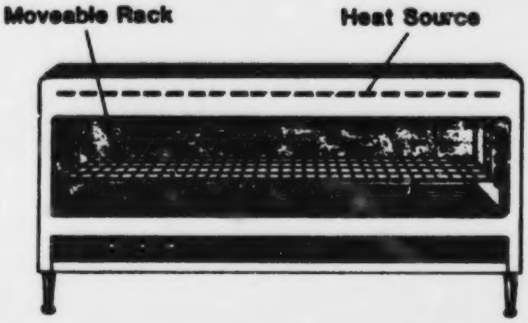

Figure 9.1 Overhead Broiler

The food is placed on a rack which can be raised, lowered and in some broiler models moved in and out. The grids on which broiling takes place are usually made of warp-resistant cast iron or steel. Drippings fall through the grid onto a tray to prevent burning and then drain into a grease trough. Because there is no burning of drippings overfired broilers cook food in a flame- and smoke-free atmosphere.

The 'backshelf broiler' or 'salamander' is a smaller version of the standard heavy-duty overfired broiler. It is usually located over the back of a range and is used primarily for browning food, melting cheese and broiling small cuts of meat.

9.2.2 Char or Underfired Broilers

The char or underfired broiler is designed to give the same effect as cooking over open coals but with less time and effort (Figure 9.2).

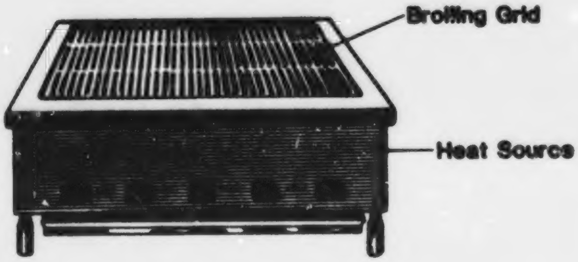

Figure 9.2 Char Broiler

The heat source is located under a heavy grid allowing the fat to drip through. The fat burns when it contacts the heat source, giving the food a distinct flavor which many people enjoy. Char broilers are usually limited to cooking meat and are often located where the customers can watch the cooking process.

9.2.3 Specialty Broilers

Specialty broilers include overfired broilers with added features such as rotating spits for cooking fowl (Figure 9.3). These rotisserie broilers have two to seven spits which rotate food in front of the heat source as it slowly broils.

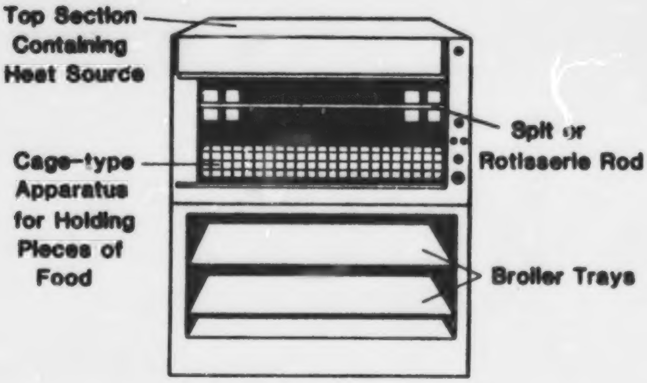
Top Section Containing Heat Source
Spit or Rotisserie Rod
Cage-type Apparatus for Holding Pieces of Food
Broiler Trays

Figure 9.3 Infrared Rotisserie and Broiler

Specialty broilers also include conveyor broilers, which have a continuous belt with a heat source above and below the belt. The belt can be timed to cook food of varying thicknesses and to different degrees of doneness.(85)

9.2.4 Electric Broilers

Overfired, char and specialty broilers are available with radiant electric elements. The elements heat to over 540°C (1000°F) producing the radiant heat required for the direct broiling of food. In some char broilers ceramics are used with the electric elements (Figure 9.4). Ceramics extend the life of the electric elements by protecting them from the fat drippings but still give the meat a charred flavor.(86)

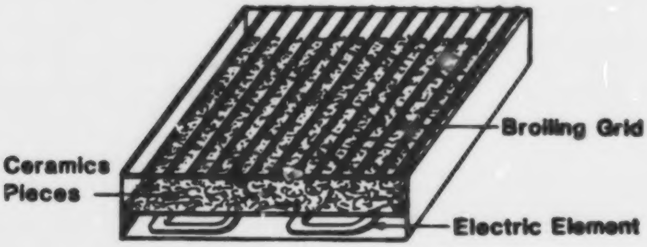

Figure 9.4 Electric Broiler Using Ceramics in Conjuction with Electric Elements

There is also a special type of electric char broiler with the elements recessed into the grate instead of situated under the grate (Figure 9.5). Meat placed on the grate cooks by conduction rather than radiation.

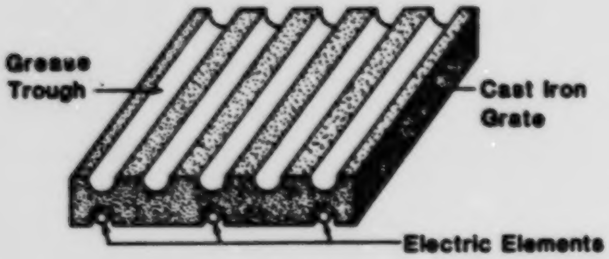
Grease Trough
Cast Iron Grate
Electric Elements

Figure 9.5 Char Broiler with Electric Elements Recessed into the Grate

9.2.5 Gas-Fired Broilers

Two types of gas-fired heat sources are available for broilers. One type uses a conventional bar-type burner which heats broken pieces of ceramics or preformed ceramic briquettes. Ceramics heated to 800 to 1100°C (1500 to 2000°F)(87) glow, providing a radiant heat source for cooking. A disadvantage of this system is the long preheating time (15 to 20 min) which is required.(7)

The other type of gas-fired heat source uses infrared burners. The gas burns in either a porous brick or a burner with special metal wings (Figure 9.6). When the burner is operating, the surface of the brick and the metal wings produce infrared rays. Preheat times for this type of broiler are only 30 to 90 s, therefore, the unit can be turned off when not in use.(88)

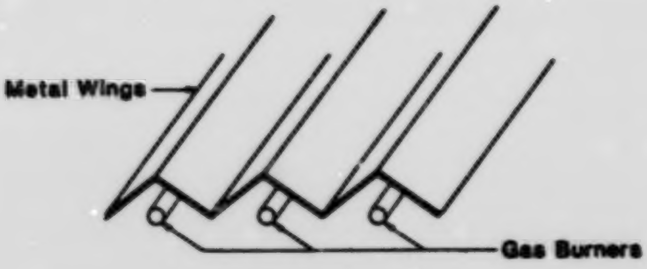

Figure 9.6 Gas-Fired Broiler with Metal Wings

Both types of gas-fired heat sources are used in char and overfired broilers. The bar-type burner with hot ceramics is especially popular in char broilers because the drippings do not contact the burners.

9.3 Energy Consumption of Broilers

9.3.1 Energy-Saving Features

Electric and gas-fired radiant burners often have preheat times of less than 60 s, therefore, the unit can be turned off whenever the broiler is not in use. One manufacturer uses a quartz heat source which operates only when a pan or plate is placed on the rack.(89)

Gas-fired broilers which use ceramics heated by a burner (e.g. char broilers) have preheat times of up to 20 min.(7) Because it is impractical to turn these broilers off during slack periods, a gas control system should be used. Such a system uses only enough gas to maintain the preheated condition, by reducing the flow of gas to the broiler by approximately 80%. The full flow of gas is immediately resumed by pushing a button, resulting in the proper broiling temperature being attained in a few seconds.

9.3.2 Energy Comparison

Electric broiler elements convert energy to radiant heat more efficiently than gas-fired sources. More of the electric energy reaches the food as radiant heat, with only a small portion lost to the surrounding air by convection. Because gas systems waste energy by venting hot combustion products, all electric broilers are more energy efficient.

The ceramics, bricks or metal wings of gas broiler systems have a large surface area which, when heated, has a high output of radiant energy. However, burner-heated ceramic systems waste energy because of long preheat times. Infrared burners are more efficient because the flames are contained within the ceramic brick or between the metal wings.(90)

A char broiler with electric elements recessed directly in the grid cooks by conduction and is more efficient than a broiler which cooks by radiation. Direct contact of the food with the heat source reduces energy loss.

In some areas of Canada gas-fired broilers may be less expensive to operate than electric broilers. To determine which broiler has the lower operating cost, the restaurant owner must compare the energy consumption of each type of unit and the local cost of gas and electricity.

9.4 Application of Broilers

Broilers are not very versatile pieces of cooking equipment. They are used mainly for cooking fatty meats, poultry and fish. Less fatty meats and fish become too dry unless they are marinated before cooking. Broilers are also used to brown and give a crisp exterior to foods such as casseroles which have been cooked by other methods. Other applications of broilers include cooking vegetables (e.g. tomatoes) and melting cheese.(91)

The skill of the cook greatly affects the quality of broiled food. The thickness, density and fat coating of the food all affect the length of time the food is cooked before it is turned. These three factors also affect the distance the food is placed from the heat source.(92) Exact timing is a necessity; cooking occurs quickly because of the high temperatures produced by the broiler.

The efficiency of a broiler depends largely on the amount of food cooked at one time. When a broiler rack or grid is only partially loaded, much of the heat is radiated into the room and wasted.(71)

Procedures which reduce energy consumption when using a broiler include:

- Turning infrared broilers off when not in use. Other broilers should be turned to medium or low. Reason: Preheating times for infrared broilers are only 60 s.(61) Other broilers turned to low when not in use will radiate less heat to the surroundings than when at higher settings.

- Cleaning ceramics on a regular basis.
  Reason: Grease and carbon deposits on the ceramics inhibit the efficient transfer of radiant heat to the food.(71)

- Cleaning broiler grids daily.
  Reason: Shiny surfaces emit less radiant heat to the surroundings.

10.1 Introduction

Steam as a source of heat may be used directly or indirectly for the cooking process. When used directly, the steam is injected into the cooking cavity of a steamer where the heat is transferred from the steam to the food. Indirect steam heating occurs in steam-jacketed kettles where the steam is used to heat the sides of the container in which the food is placed. The sides of the container then heat the food by conduction.

The change of phase from a liquid to a vapor takes place under equilibrium conditions (constant temperature and pressure) and requires the addition of a relatively large amount of heat (the latent heat of vaporization). When condensation occurs the heat is released. This is the principle on which all steam equipment works and is the reason for its efficiency and temperature stability. The object on which the steam condenses absorbs the latent heat of vaporization.(93) Once the flow rate of the steam is set the rate of heat transfer remains constant and takes place at a constant temperature.

There are two types of steam equipment: self-contained and direct steam.(94) Self-contained equipment has a steam generator as an integral part of the equipment and the generator is usually designed for operating that particular piece of equipment only. Direct steam equipment, on the other hand, has a separate source of steam for operating the equipment. Steam may be generated in a boiler attached to the steam equipment or in a remote boiler which serves a number of units. If there is a steam supply, but the steam is not pure enough for contact with food a steam-heat exchanger may be installed. The exchanger takes the heat from impure steam and transfers it to potable water, which then becomes pure steam.(95) Gas-fired boilers operate at a steady state efficiency of about 85%. Electric boilers generate steam essentially at 100% efficiency.

Because of the danger associated with the use of steam under pressure, a number of safety devices are required. Pressure gauges monitor the pressure in the system; if the pressure exceeds a preset limit safety valves vent the steam. Boilers are usually equipped with water level indicators to prevent the water level from dropping below dangerous levels.

10.2 Steam-Jacketed Kettles

The most common piece of steam cooking equipment is the steam-jacketed kettle. Steam kettles are constructed like large double boilers and range from 1 to 750 L (1 qt. to 200 gal.)(96) in capacity. The condensing chamber is contained between two hemispherical shells, of different sizes, which keep the steam separate from the food (Figure 10.1). As the steam condenses on the outside of the inner shell it gives up the latent heat to the metal and the condensate drips to the bottom of the outer shell. The heat transfers from the inner shell to the food by conduction.

The temperature of the kettle can be varied from 85°C (185°F), a gentle simmer, to 145°C (290°F), a rolling boil, by adjusting the flow of the steam into the condensing chamber.(97)

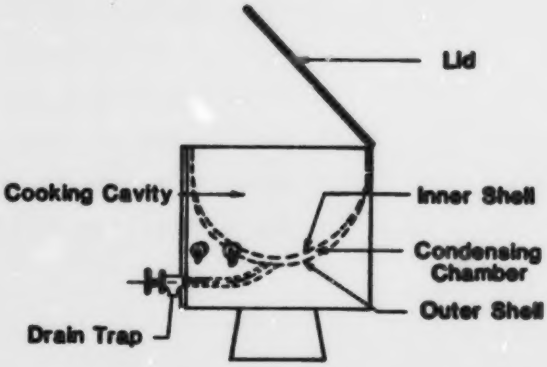

Figure 10.1 Steam Kettle

10.3 Steamers

Equipment that uses steam directly cooks food by extracting the latent heat of vaporization from the steam as it condenses on the food. Steamers are divided into three main types:

1) atmospheric,
2) convection and
3) pressure steamers.

Units which can operate as both atmospheric and pressure steamers are also available.

10.3.1 Atmospheric Steamers

Atmospheric steamers have unpressurized cooking cavities and rely on natural convection to carry the steam to the food (Figure 10.3). The steam enters at the bottom of the steamer or is generated by boiling water in the bottom of the cooking cavity. The food is placed in pans, with or without perforated bottoms, that are suspended in the cooking cavity. The steam rises from the bottom of the cavity and condenses on the pan and the food. Since the steam tends to condense on the first tray encountered, food at the top of the steamer takes longer to cook.

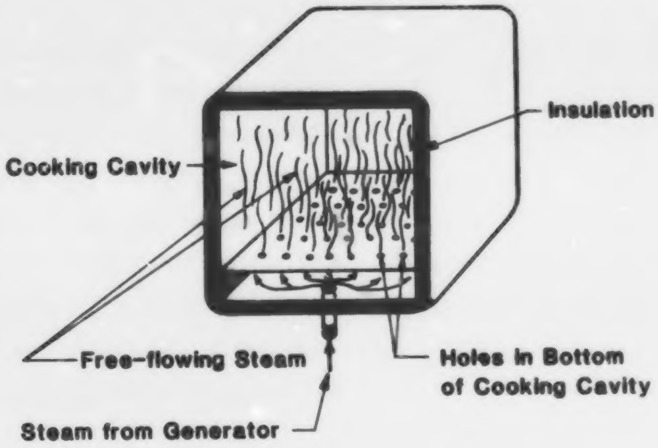
Insulation
Cooking Cavity
Free-flowing Steam
Holes in Bottom of Cooking Cavity
Steam from Generator

Figure 10.2 Atmospheric Steamer

10.3.2 Convection Steamers

Convection steamers also have unpressurized cooking cavities, but use forced convection to carry the steam to the food (Figure 10.4). The steam is injected through ports in the walls of the cooking cavity and is directed evenly around the food. The continuous motion of the steam reduces the air and water layers which normally surround and insulate the food. In addition, cooking of several trays of food at one time occurs more evenly.

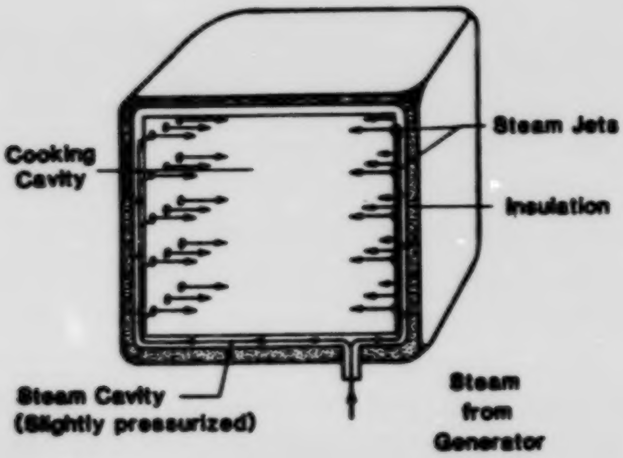
Steam Jets
Cooking Cavity
Insulation
Steam Cavity (Slightly pressurized)
Steam from Generator

Figure 10.3 Convection Steamer

10.3.3 Pressure Steamers

Pressure steamers maintain pressures from 35 to 100 kPa (5 to 15 psi) in the cooking cavity.(98) The temperature of the steam in the cooking cavity increases as the pressure increases. For example, at 100 kPa (15 psi) the steam temperature is 121°C (250°F)(99) compared to 100°C (212°F) at atmospheric pressure. Because the food is exposed to a higher steam temperature cooking in a pressure steamer is faster than in an atmospheric steamer (Figure 10.5).

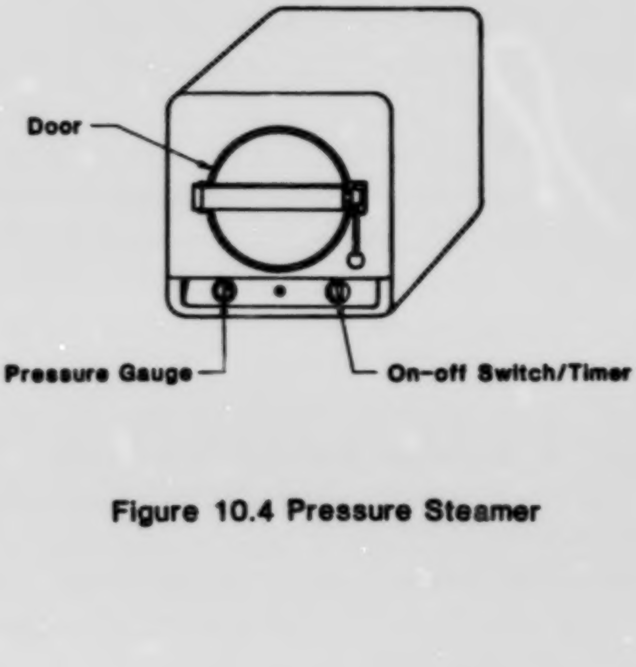

Figure 10.4 Pressure Steamer

10.4 Energy Comparison of Steamers

Because of the inefficient transfer of heat from the range to the pot, cooking food in a pot on a range is less efficient than cooking in a steamer.(100)

Pressure steamers are more energy efficient than atmospheric steamers for cooking some foods (e.g. vegetables and fish).(101) Approximately twice as much energy is involved when using steam at 100 kPa (15 psi) than at atmospheric pressure(102); thus cooking times for pressure steamers are 65 to 90% less.(103)

10.5 Application of Steam Equipment

10.5.1 Steam-jacketed Kettles

Steam-jacketed kettles and are highly versatile pieces of equipment which can be used to boil, braise, poach, sauté, simmer, steam, and stew food.(104) They have the additional advantage of reducing the possibility of scorching because of the even distribution of heat.

Steam-jacketed kettles are labor-saving because all of the preparation steps for dishes such as beef stroganoff and chicken à la king can be carried out in the kettle.(105) The vegetables can be sautéed, the meat braised and, finally, other ingredients added producing a finished product in one piece of equipment.

Energy use can be reduced by 5 to 10%(106) by closing the cover on a steam-jacketed kettle when heating food to the cooking temperature. When the cooking temperature has been reached the energy required to maintain that temperature is reduced by keeping the cover closed.

Other procedures which reduce energy consumption when using steam-jacketed kettles include:

- Loading kettles to maximum capacity according to manufacturer's directions.
  Reason: Under-filled equipment means that heat is lost to the air above the food. In addition, the energy consumed per kilogram of food is greater.

- Turning equipment off a few minutes before cooking is completed.

  Reason: This allows food to finish cooking in the residual heat of the kettle rather than losing the heat to the surroundings.

- Promptly repairing all steam leaks no matter how small.

  Reason: A 3 mm (1/8 in.) diameter steam leak in a 690 kPa (100 psi) line will cause the loss of 23,000 kg (50,000 lb.) of steam per month.(107)

- Maintaining proper insulation on steam lines and exposed components.

  Reason: Adequate insulation on steam lines reduces heat loss to the surroundings.(108)

- Removing hard water deposits regularly from heat transfer surfaces.

  Reason: Scale acts as an insulator which retards the transfer of heat.(109)

10.5.2 Steamers

Cooking in a steamer is fast and efficient because the steam contacts the food directly. Steamers can be used to cook all foods except those requiring a crust or a browned appearance.(110) Pressure steamers are ideally suited to cooking fresh foods, particularly those which require more than 15 min of cooking by other methods.(111) Convection steamers are most useful for cooking frozen foods because the moving air promotes faster, more even heating.(112)

Steam cooking is less labor intensive than range top cooking. Once the food is placed in the steamer, the timer set and the steam turned on, the food needs no additional attention until the end of the cooking time.

The short cooking times possible in steamers allow small quantities of food to be prepared quickly and frequently. This eliminates the leftovers often associated with quantity food preparation.

Vegetables cooked in a steamer have a brighter, fresher appearance and retain more of their nutrients because of the short cooking times. However, the short cooking times mean that timing is critical particularly for green vegetables. Several different foods can be cooked in a steamer at the same time. The steam will not transfer the flavor of one food to another, providing the foods are in different pans.(114)

Procedures which reduce the energy consumed by steamers include:

- Filling steamers to manufacturer's stated capacity.
  Reason: Because the amount of steam input into a steamer is constant, the steam used per serving decreases.

- Using timers to automatically control cooking time rather than opening steamers to check on product 'donrness'.
  Reason: Each time the steamer is opened steam which could be used for cooking is lost to the surroundings.

- Cleaning debris from door seals and replacing gaskets.
  Reason: This prevents steam from escaping to the surroundings.

- Promptly repairing all steam leaks no matter how small.
  Reason: A 3 mm (1/8 in.) diameter steam leak in a 690 kPa (100 psi) line will cause the loss of 23,000 kg (50,000 lb.) of steam per month.(107)

- Maintaining proper insulation on steam lines and exposed components.
  Reason: Adequate insulation on steam lines reduces heat loss to the surroundings.(108)

- Removing hard water deposits regularly from heat transfer surfaces.
  Reason: Scale acts as an insulator which retards the transfer of heat.(109)

11.1 Introduction

Tilting skillets are rectangular-shaped, flat-bottomed kettles with four continuous vertical sides. They are also referred to as tilting frypans or tilting griddles. The cooking compartments are 18 to 23 cm (7 to 9 in.) deep and range in capacity from 87 to 150 L (23 to 40 gal.)(37) The temperature of the tilting skillet can be varied from 40 to 220°C (100 to 425°F).(137)

Tilting skillets are usually floor-mounted, but they may also be wall-mounted on brackets or table top-mounted. They are equipped with a pouring lip and a self-locking tilt mechanism for easy removal of liquid foods such as sauces and stews. The tilting mechanism also makes the skillet fast and easy to clean. Most tilting skillets also are equipped with a hinged lid which is counterbalanced to prevent it from closing accidentally.

The bottom of the tilting skillet is heated by gas burners or electric elements. Steam-jacketed tilting skillets can be found in some restaurants but they are no longer manufactured.

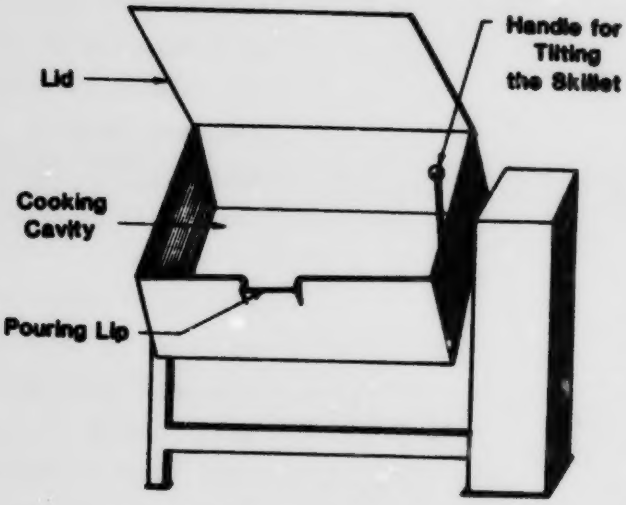
Lid
Handle for Tilting the Skillet
Cooking Cavity
Pouring Lip

Figure 11.1 Tilting Skillet

11.2 Variations of Design

11.2.1 Electric Tilting Skillets

Electrically-heated tilting skillets have electric resistance elements which are enclosed in tubes and clamped to the underside of the bottom of the skillet in a manner similar to a hot top range (Figure 6.3). Heat is transferred from the elements to the bottom of the skillet by conduction. The food, which is in direct contact with the bottom, is cooked by conduction.

11.2.2 Gas-fired Tilting Skillets

Gas-fired tilting skillets have gas burners placed across the entire underside of the bottom of the skillet to provide maximum coverage. The hot gases from the burners pass under the skillet bottom and are vented out the back of the skillet. Heat is transferred from the combustion products to the skillet bottom mainly by convection and, to a small degree, by radiation. Food placed on the bottom of the skillet cooks by conduction.

11.3 Energy Consumption of Tilting Skillets

11.3.1 Energy-Saving Skillets

Gas-fired tilting skillets should be equipped with electric ignition systems rather than pilot lights. Pilot lights use gas 24h per day, although the skillet may be used for only a few hours. Electric ignitions allow gas to be consumed only when the skillet is in operation. The savings possible depend on the amount of time the skillet is in use. Restaurants which use their tilting skillets only intermittently will benefit more than restaurants which use their skillets almost continuously.

Electric tilting skillets which have a large mass of a metal with the ability to store heat (e.g. aluminum) attached to the skillet bottom require smaller (lower kilowatt rating) heating elements than skillets without the metal attached. The smaller heating elements mean that the electrical demand of the tilting skillet is less.

11.3.2 Energy Consumption of Tilting Skillets

Regardless of the energy source of a tilting skillet heat is lost to the surrounding air from any portion of the cooking surface not covered by food.

Gas-fired tilting skillets are less efficient than electric models because a portion of the heat produced by the burners is lost when the hot combustion products are vented. In some areas of Canada gas-fired skillets may be less expensive to operate than electric skillets. To determine which tilting skillet is most efficient to operate, the restaurant owner must compare the energy consumption of each type of skillet and the local cost of the energy types available.

11.4 Application of Tilting Skillets

Tilting skillets are versatile pieces of cooking equipment which can perform a wide variety of cooking functions including boiling, braising, poaching, sautéing, simmering, steaming and shallow frying.(104) Successive cooking functions can be carried out in a tilting skillet without having to move food from one piece of equipment to another. For example, beef stroganoff and chicken à la king can both be prepared from the raw food stage to the completed product in one piece of equipment. Vegetables can be sautéed, the meat braised and, finally, other ingredients added.

Tilting skillets are generally considered to be underpowered for deep frying.(116) In addition, baked products in the skillet brown on the bottom, but not on the top.(117)

Procedures which reduce energy consumption when using a tilting skillet include:

- Filling skillets to maximum capacity according to manufacturer's directions.
  Reason: Partially-filled skillets mean that heat is lost to the surroundings.

- Closing the cover on the skillet when heating food to the desired cooking temperature.
  Reason: Less heat will be lost to the surroundings so the food will heat faster.

- Turning the skillet off a few minutes before cooking is completed.
  Reason: This allows food to finish cooking in the residual heat of the skillet rather than losing the heat to the surroundings.

- Checking thermostat accuracy regularly and recalibrating as necessary.
  Reason: If the skillet reaches a temperature higher than the temperature which was preset, the rate of heat transfer to the surroundings will increase because of the greater temperature differential.

- Preheating the skillet no longer than recommended by the manufacturer.
  Reason: If the skillet is not used immediately after it reaches the temperature required, then heat which could be used productively to cook food is lost to the surroundings.(68)

- Cleaning the skillet surface after each use.
  Reason: A shiny surface emits less radiant heat to the surroundings. Food particles on the skillet act as an insulating layer and inhibit efficient heat transfer.(71)

Food processing equipment includes food mixers, cutters, grinders, peelers and saws. All of these units use energy but the amount is negligible compared to the total energy consumption during food preparation. Generally this equipment is powered by small electric motors which use little energy. For example, the motor of a 68 L (60 qt.) mixer uses only 0.38 kW.(118) This rate of power consumption is less than one-third of that used by a conventional household toaster (1.5 kW).

13.1 Introduction

Cleanup equipment consist of disposers and dishwashers. Disposers grind and flush food waste directly into the sewage system using a continuous flow of water. Disposers use little energy because they are driven by low-power electric motors and are not operated continuously. Dishwashers, however, are major energy consumers because they use large quantities of hot water and are often operated continuously for long periods. Therefore, the remainder of this section will deal with the various types of dishwashers and their operation.

The actual washing of dishes is only one phase of the complete dishwashing operation which includes scraping of surface waste, presoaking, washing, rinsing, sanitizing and drying.(119)

Scraping is the removal of gross soil from dishes before placing them in the dishwasher. Scraping is necessary to avoid placing an undesirable load on the dishwasher. Soil that is removed is washed into a disposer or placed in the garbage.

Dishes and silverware with soil that is too 'dried-on' to be removed in the dishwasher must be presoaked. The dishes are placed in a tray of warm water and detergent until the soil softens.

The first operation performed in the dishwasher is the washing of the dishes. A mixture of hot water, at 60 to 70° C (140 to 160°F), and detergent(120) is sprayed on the dishes to loosen and wash the soil from the dishes.

The rinsing phase of the dishwashing operation removes the detergent and any residual soil left after the washing phase. This is performed with water at 70°C (160°F)(120).

Sanitizing destroys potentially dangerous bacteria which grow in food residue on dishes. The bacteria can be destroyed using one of two methods. In high temperature machines, the dishes are heated to over 72°C (161°F) by using a high temperature, 80°C (180°F), final rinse.(120) The water temperature is raised to 80°C (180°F) by a booster heater. Alternately, low temperature dishwashers use final rinse water at 50 to 60°C (120 to 140°F)(121) which contains a chemical sanitizing agent such as chlorine.

Dishwashers dry dishes by heating them to the point where moisture evaporates from the dishes.

Three main designs of dishwashers are available:

1) stationary rack,
2) conveyer and
3) flight.

Each design is available in both high- and low-temperature models.

13.2 Variations of Design

13.2.1 Stationary-Rack Dishwashers

When loading stationary-rack dishwashers, the dishes are placed on a rack after being prescraped. The rack is then placed in the dishwasher where the washing, rinsing and sanitizing operations take place in the same chamber (Figure 13.1). The racks are removed from the machine and placed on tables or shelves to dry.

The capacity of stationary rack dishwashers ranges from 12 to 120 racks per hour.(122)

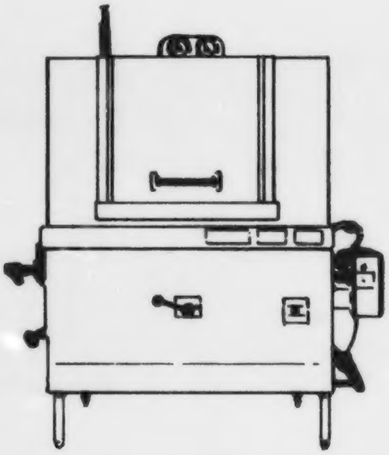

Figure 13.1 Stationary-Rack Dishwasher

13.2.2 Conveyer Dishwashers

Conveyer dishwashers use a conveyer to move racks of dishes through the machine (Figure 13.2). Motor-driven chains pull the conveyer into the machine where the dishes are washed, rinsed and sanitized in one chamber or in separate chambers. Drying takes place on separate tables after the trays are taken off the conveyer.

The capacity of conveyer dishwashers ranges from 126 to 468 racks per hour.(122)

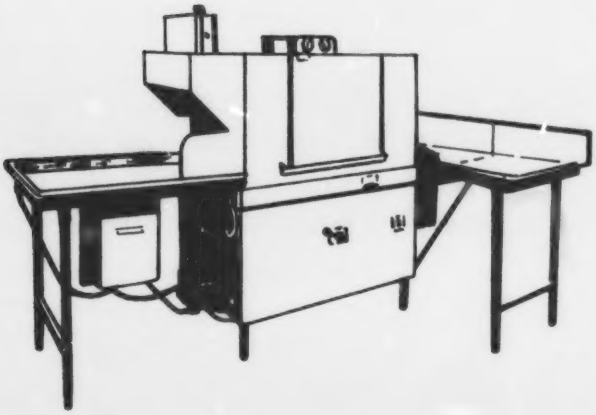

Figure 13.2 Conveyor Dishwasher

13.2.3 Flight Dishwashers

Flight dishwashers are used by very large restaurants or cafeteria-style operations. Flight dishwashers have long conveyers which extend out both ends of the machine where the dishes are continuously loaded and dried (Figure 13.3). Washing, rinsing and sanitizing take place continuously in separate chambers. Drying may be accelerated by the use of hot air blowers, allowing dishes to be removed and stored immediately after leaving the dishwasher.

The capacity of flight dishwashers ranges from 5 250 to 22 600 dishes per hour.(122)

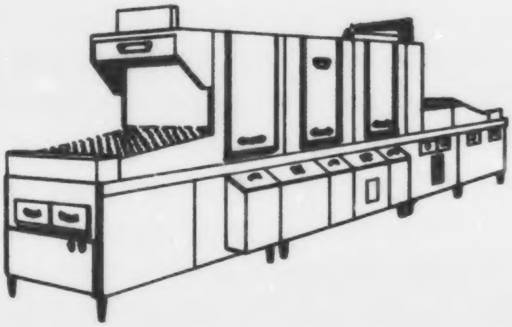

Figure 13.3 Flight Dishwasher

13.3 Energy Consumption of Dishwashers

13.3.1 Energy Saving Features

In an effort to reduce the high cost of operating booster heaters, low-temperature dishwashers were developed (Figure 13.4). The primary differences between low-temperature and high-temperature units are the rinsing temperature and the drying time. High-temperature machines wash dishes in water at 60 to 70°C (140 to 160°F)(120) rinse with water at 80°C (180° F) for sterilization. Low-temperature machines wash dishes with water at 50 to 60°C (120 to 140°F)(121) and rinse with water at 50 to 60°C (120 to 140°F)(121) containing a chemical sanitizing agent. The 20 to 30°C (30 to 40°F) decrease in rinse water temperature results in energy savings for low-temperature dishwashers.

After sanitization, the dishes are removed from the machine for drying. Drying times are considerably longer for dishes washed in low-temperature machines than for dishes washed in high-temperature models because of the lower rinse temperature used.

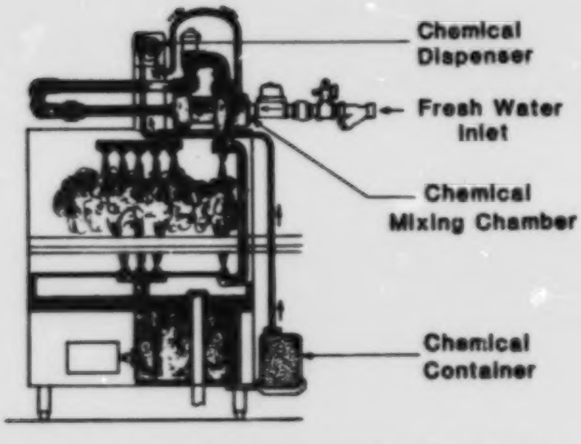

Figure 13.4 Low-Temperature Dishwasher

Manufacturers of all types of dishwashers also are attempting to reduce hot water consumption through the use of improved spray systems. These systems use high pressure spray which penetrates even small crevices to flush out dirt. The fine, high pressure spray is more effective than a conventional spray and uses less hot water.(123)

13.3.2 Energy Comparison

The type and size of dishwasher required by a restaurant depends primarily on the size of the restaurant. A dishwasher which is too large increases hot water consumption, while one that is too small increases the required labor. Once a particular type and size of dishwasher has been selected, a decision must be made between a high- or low-temperature model. The cost of hot water compared to the cost of sanitizing chemicals, the purchase or leasing cost, the increased drying time, and the increased labor cost must be evaluated. In addition, there is a considerable amount of controversy regarding the effectiveness of low-temperature models. While many owners are satisfied with the low-temperature models, others complain that a chemical film remains on the dishes after rinsing and that drying times are extremely long.

13.4 Application of Dishwashers

Dishes should be scraped of food debris before they are placed in the dishwasher. Dishes and silverware should be washed as soon as possible after use so soil does not dry on.

The energy consumption of a dishwasher can be reduced by:

- Operating the dishwasher fully loaded.
  Reason: Washing a partial load uses the same amount of energy as washing a full load. Therefore, the energy cost per dish is higher for a partial load.

- Using a dishwasher of the correct size for the warewashing volume of the restaurant.(124)
  Reason: An oversized dishwasher wastes energy because it is not filled to capacity.

- Setting thermostats to maintain water temperatures at 50 to 60°C (120 to 140°F) for wash water and 80°C (180°F) for final rinse water.
  Reason: Final rinse water that is hotter than 80°C (180°F) provides no extra benefit, wastes heat and accelerates the build-up of deposits in the booster heater.

- Locating hot water boosters as close as possible to dishwashers.
  Reason: This reduces the heat loss from the extra piping.

- Insulating exposed hot water pipes.
  Reason: This reduces the heat loss to the surroundings.

- Keeping water pressure between 100 and 175 kPa (15 and 25 psi).
  Reason: Dishwasher cycles are timed for water flow rates which occur at these pressures. Excessive pressure increases the flow rate and, therefore, the amount of hot water used without increasing dishwasher effectiveness.

- Inspecting feed and drain valves for leakage and repairing if necessary.
  Reason: A leaking drain valve results in the loss of hot water before it is used to clean the dishes.

- Removing water deposits from heater elements on a regular basis.
  Reason: These deposits act as an insulating layer which retards the transfer of heat from the elements to the water.

14.1 Introduction

Perishable foods are kept in refrigerators or freezers to extend the freshness of the food, to prevent rapid spoilage and, in some cases, to inhibit bacterial growth in the food.(125) Cold storage equipment includes refrigerators and storage freezers. Refrigerators are kept between 0 and 4°C (32 and 40°F),(126) while a storage freezer is kept at -18°C (0°F)(127) or lower. Storage freezers are most suitable for holding food which is already frozen although some restaurants freeze food in storage freezers. Actual freezing is best performed by blast freezers, especially when large quantities of food must be frozen.

The process of refrigeration is defined as the continual transfer of heat from a region of low temperature to one of higher temperature. A vapor compression refrigerator consists of a compressor, condenser, expansion valve, evaporator and refrigerant which is the working fluid of the system (Figure 14.1).

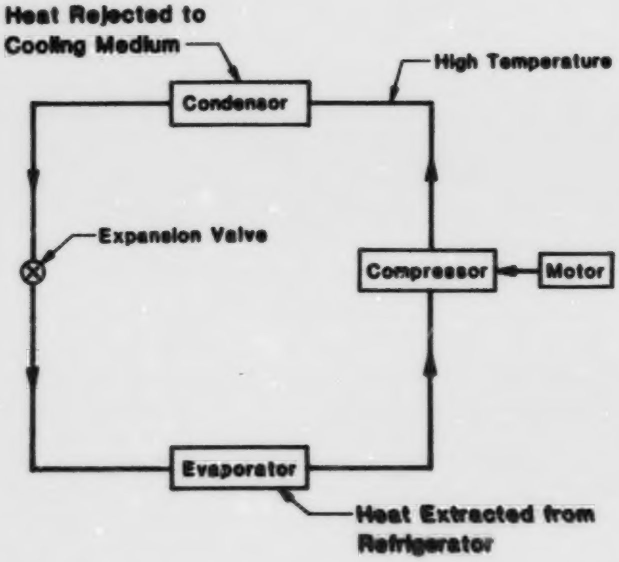
Heat Rejected to Cooling Medium
High Temperature
Condenser
Expansion Valve
Compressor
Motor
Evaporator
Heat Extracted from Refrigerator

Figure 14.1 Equipment Diagram for a Vapour-Compression Refrigerator

The refrigerant enters the compressor as a vapor at a low temperature and pressure and leaves at a high temperature and pressure. In the condensor, heat is extracted from the refrigerant which leaves as a liquid at a high pressure. An expansion valve reduces the pressure and, therefore, the temperature of the liquid, causing partial vaporization. The liquid-vapor refrigerant is completely vaporized in the evaporator, absorbing heat from the space being cooled.(128)

14.2 Variations of Design

The type of condenser in a refrigeration system is an important factor to consider when purchasing a refrigerator or freezer. The condenser converts the high temperature refrigerant from a gas to a liquid by removing heat and transferring this heat to air or water. An air-cooled condenser (Figure 14.2) transfers the removed heat to the ambient air.

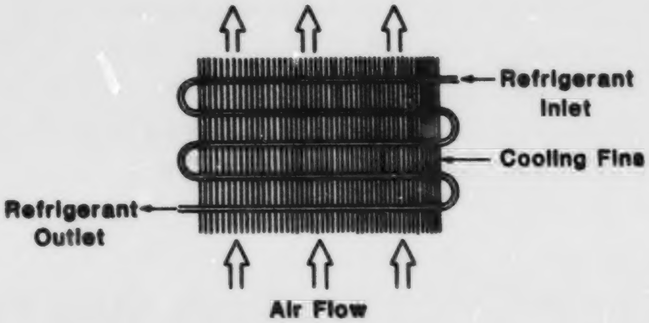
Refrigerant Inlet
Cooling Fins
Refrigerant Outlet
Air Flow

Figure 14.2 Air - Cooled Condenser

A water-cooled condenser (Figure 14.3) transfers the removed heat to water obtained from the restaurant's water supply. The resulting hot water is normally dumped down the drain.

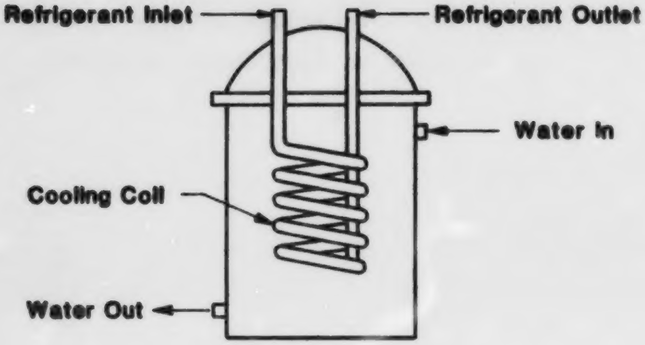
Refrigerant Inlet
Refrigerant Outlet
Water In
Cooling Coil
Water Out

Figure 14.3 Water-Cooled Condenser

14.3 Energy Consumption of Cold Storage Equipment

14.3.1 Energy-Saving Features

Heavily insulated walls free from heat leaks are necessary in all refrigerators to reduce heat gain from the surrounding area. The resistance that a wall has to heat transfer is called the 'R' value*. A wall with a large 'R' value is a better insulator than one with a small 'R' value.(129) For example, 8 cm (3 in.) of plywood is required to produce the same 'R' value as 2.5 cm (1 in.) of glass wool. Use of 'R' values allows the restaurant owner to compare the insulating properties of different cold-storage units. It is important that the 'R' value of a refrigerator door be equal to that of the walls. Equally important is the quality of the seal around the door and the absence of any direct contact of heat-conducting material between the inside and the outside of the refrigerator.

A refrigerator may absorb more heat through an open door in a few minutes than it will through the walls in a whole day. Overlapping plastic strips which hang from the top of the doorway can be used to reduce heat gain from open refrigerator or freezer doors (Figure 14.4). The strips allow traffic to pass through the doorway while preventing the cold air from the refrigerator from escaping.(130) Manufacturers claim savings of up to 45% when such plastic strips are used.(131)

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* Instead of 'R' values some manufacturers specify "K" values. A 'K' value is the thermal conductance of a wall and is the reciprocal of the 'R' value (thermal resistance). A wall with a low 'K' value is a better insulator than one with a high 'K' value.

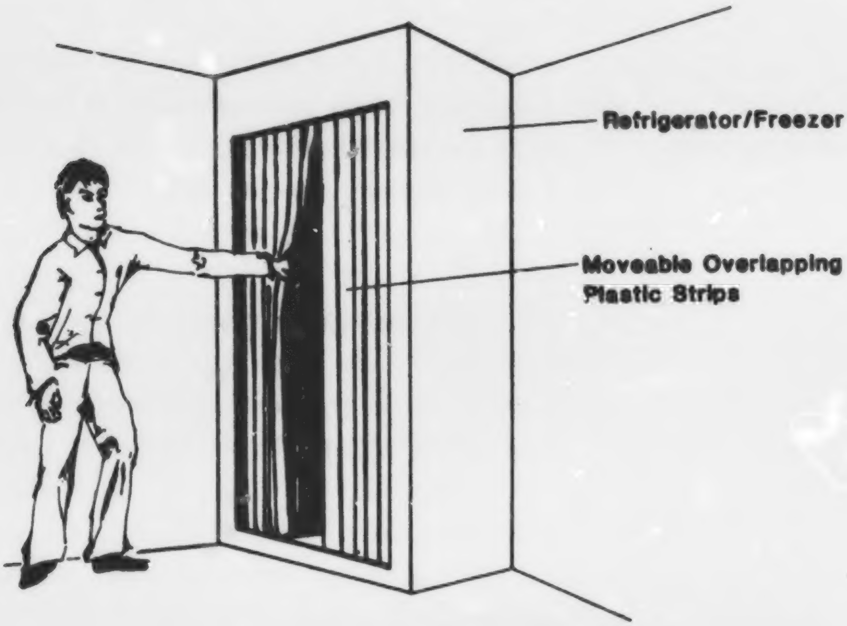
Refrigerator/Freezer
Moveable Overlapping Plastic Strips

Figure 14.4 Flexible Plastic Strips for Refrigerators

14.3.2 Energy Comparison

Water-cooled condensers are less expensive and more compact to purchase than air-cooled units. However, the operating costs are greater because water is used to carry away the heat. The heat extracted from the hot water in a water-cooled condenser may be recovered in a heat exchanger to provide additional energy for a hot water system.(132)

Air-cooled condensers do not have a direct operating cost but the heat is often discharged into the restaurant. In cold weather, this reduces the load on the main heating system but in hot weather a heavier load is placed on the air-conditioning system. In areas which require air-conditioning for a large part of the year, a central refrigeration plant can be located outside the building with separate refrigerant lines running to each cold-storage unit. The condenser heat is then exhausted to the outside air instead of to the air inside the building.(132)

14.4 Application of Cold Storage Equipment

The following procedures should be followed to reduce the amount of energy consumed by cold storage equipment.

- Check thermostat accuracy. Refrigerators should be kept between 0 and 4°C (32 and 40°F)(126) and freezers at -18°C (0°F)(106) or lower.
  Reason: Refrigerators and freezers kept at temperatures that are lower than necessary use additional energy with no added benefits.(133)

- Avoid opening refrigerators and freezers frequently. The use of mobile racks allows more food items to be removed with one opening of the door.
  Reason: An open door allows warm air to enter and energy must be used to extract this heat from the cold storage unit.

- Install signal lights outside walk-in units to warn when lights have been left on inside.
  Reason: Lights generate heat which must be extracted.

- Adjust free-standing upright cold-storage units so that the doors will automatically swing shut from an open position.
  Reason: This procedure limits the time that doors remain open and, therefore, reduces the amount of warm air entering the unit.

- Cool hot foods to 60°C (140°F), but not lower, before refrigerating or freezing. Foods kept between 4 and 60°C (40 and 140°F) are susceptible to bacterial growth.(134)
  Reason: The higher the temperature of a given weight of food, the greater the amount of heat which must be removed from the cold-storage unit and, therefore, the greater the energy consumption.(135)

- Thaw frozen foods in the refrigerator.
  Reason: As food thaws it cools the surrounding air, decreasing the load on the refrigeration system.(136)

- Place cold and frozen food in the appropriate storage area immediately upon delivery.
  Reason: To prevent the temperature of the food from increasing. Any heat absorbed by the food must eventually be extracted by the cold storage unit.(137)

- Choose the smallest cold storage unit possible that suits the storage requirements of the restaurant.
  Reason: The heat gain through the walls increases with the size of the unit, requiring more energy for heat extraction.

- Organize the refrigerator and freezer space so that frequently used items are near the front.
  Reason: This reduces the amount of time that the door is open and, therefore, the amount of heat entering the unit.

- Replace all worn or damaged door gaskets and seals.
  Reason: This reduces the amount of heat which enters the cold storage unit.

- Keep an open space of at least 1 m (3 ft.) in front of the evaporator coils in walk-in units.
  Reason: This allows heat from the refrigerated space to be easily extracted.

- Defrost freezers regularly, allowing no more than 3 mm (1/8 in.) of ice to build-up on the cooling coils.
  Reason: Ice acts as an insulator, reducing the effectiveness of the cooling unit.

- Trim food products before storing.
  Reason: This reduces the mass of food being chilled or frozen.

- Wrap food products properly.
  Reason: This prevents excess moisture from escaping from the food which will form frost on the sides of the cold storage unit and on the evaporator coils. Proper wrapping also preserves the taste and texture of the stored food.(136)

15.1 Introduction

The Manufacturers' Claims section contains an evaluation of advertising claims made by cooking equipment manufacturers regarding the energy efficiency of their equipment. This evaluation is not intended to promote or degrade any product but to provide a basis for assessing the information presented in manufacturers' brochures.

The claims used as examples in this section were taken from brochures obtained at the National Restaurant Association exhibition held in Chicago in May, 1982 and at the HostEx exhibition sponsored by the Canadian Restaurant and Foodservices Association held in Toronto in April, 1982. All of the major equipment manuacturers were represented at these shows by factory representatives or dealers.

Most manufacturers' brochures use comparisons to show the relative merit of a product. However, many manufacturers do not state the basis of the comparison or the method used for the testing. This section will describe what information a claim should contain, along with examples and descriptions of claims that fall short of the ideal.

15.2 Description of a Claim

Three factors must considered when examining a manufacturer's claim:

1) the description of the particular pieces of equipment being compared,
2) the basis of the comparison and
3) the conclusions drawn from the comparison.

15.2.1 Equipment Being Compared

A claim should describe all pieces of equipment involved in the comparison, including the manufacturers' names, the models, the type of equipment (e.g. gas-fired or electric, direct or indirect-fired) and cooking capacities of the equipment. Buyers requiring additional information (e.g. dimensions, power input) about the equipment should be able to obtain it from the manufacturers' specification sheets.

Claims which do not adequately describe the pieces of equipment involved are often confusing to the reader. For example, a manufacturer of gas-fired fryers claims that their fryer

> "offers the same cooking performance as a fryer requiring 145,000 Btu* input, yet requires only 122,000 Btu input."

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* The Btu (British Thermal Unit) is a unit of energy which is approximately the heat required to raise the temperature of a pound of water from 59° to 60°F. 1 Btu = 0.239 J(37) Research quoted in manufacturers' brochures is primarily conducted in the U.S., therefore, Btu's rather than Joules are used in this section.

The brochure does not indicate the model or capacity of the "fryer requiring 145,000 Btu input" leaving the reader in doubt regarding the exact identity of the two fryers being compared.

In another brochure, a manufacturer of convection ovens states that

> "Their convection ovens have the same cooking and baking capacity as (manufacturer's name) standard models, but use up to 40% less gas."

In this case the manufacturer of the second oven is named, but no indication is given of what is meant by a "standard model".

15.2.2 Basis of the Comparison

The second factor to consider when evaluating a manufacturer's claim is the basis of the comparison between the two pieces of equipment. Many manufacturers use energy efficiency as the basis for their comparisons, but efficiency with respect to cooking equipment can be defined in several different ways.

'Combustion efficiency' is defined as the ratio of the amount of energy output by a gas burner or electric element to the amount of energy contained (heating value) in the quantity of fuel used (Figure 14.1). For example, an electric element which converts all the energy available to heat has an efficiency of 100%. Gas burners, on the other hand, seldom extract more than 700 of the possible 1000 Btu contained in a cubic foot of gas, resulting in a combustion efficiency of only 70%.

'Heat transfer efficiency' is the ratio of the amount of heat used to cook the food to the amount of heat produced by the burner or electric element (Figure 14.1). For example, if 350 of the 700 Btu produced by the gas burner are used to cook a food then the heat transfer efficiency is 50%. The heat which is not used for cooking is exhausted out the flue or lost to the surroundings.

'Overall efficiency' is defined as the ratio of the heat used to cook the food to the actual amount of energy contained (heating value) in the fuel used (Figure 14.1). The overall efficiency of a piece of equipment with a 70% combustion efficiency and a 50% heat transfer efficiency is 35%.

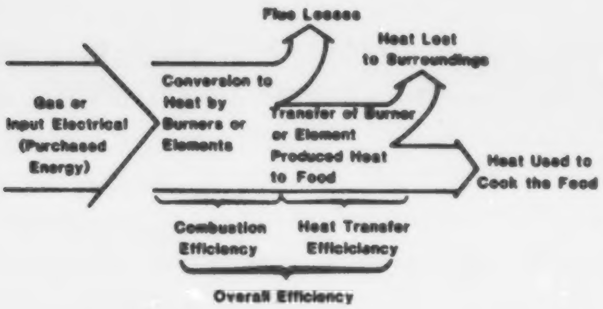
Flue Losses
Heat Lost to Surroundings
Gas or Input Electrical (Purchased Energy)
Conversion to Heat by Burners or Elements
Transfer of Burner or Element Produced Heat to Food
Heat Used to Cook the Food
Combustion Efficiency
Heat Transfer Efficiciency
Overall Efficiency

Figure 15.1 Relationships Between Different Types of Energy Efficiencies

'Energy efficiency' is a general term manufacturers often use to describe combustion, heat transfer and overall energy efficiency. Therefore, to understand the merit of claims made in manufacturers' brochures a reader must know how the manufacturer has defined energy efficiency.

For example, a gas-fired convection oven manufacturer states that their fan system

> "squeezes 40% more heat from the heated air before allowing it to be vented into the exhaust system, thereby increasing the efficiency of the oven and using less fuel to do the same amount of cooking."

This statement refers to the improved heat transfer efficiency of the oven. The brochure then states that

> "60,000 Btu input produces as much usable heat as most ovens with 100,000 Btu input!"

The second statement can be interpreted one way if read alone and differently when read in the context of the first statement. If read in the context of the first statement 'Btu input' refers to the heat produced by the burners, which is input into the heat transfer process. However, if the second statement is read alone, then the 'Btu input' could be interpreted as the Btu's contained in the gas supplied to the burners. This would lead the reader to believe that a 40% saving in overall efficiency was possible, when only a 40% saving in the heat transfer efficiency is being realized. The format of this brochure increases the likelihood of misinterpretation.

In another brochure, a manufacturer of deep fryers claims that their design

> "permit(s) over 50% more heat to be transferred to fat instantly, eliminating waits between loads."

This claim describes an improvement in heat transfer efficiency. Elsewhere in the brochure they claim:

> "We just cut the cost of gas frying over 30%."

This 30% savings refers to the overall efficiency of the fryer and illustrates how a large improvement in heat transfer efficiency resulted in a much smaller improvement in overall efficiency. In contrast to the previous example, it is always clear in this example what type of efficiency is being described.

In addition to improved energy efficiency, manufacturers often report improvements in design in terms of a decrease in the energy used per weight of product cooked (eg. Btu/lb.). This type of claim demonstrates the savings which result by increasing the capacity of the equipment while keeping the energy consumption constant.

This type of comparison also allows pieces of equipment with different capacities or different rates of energy consumption to be compared. Such a comparison must include:

1) a description of the product tested,
2) the amount of product cooked in each piece of equipment and
3) the total amount of energy consumed in the cooking process.

For example, a manufacturer of convection ovens presented data for baking brown-and-serve rolls in their convection oven and in a conventional oven. The convection oven baked three pans of rolls in 12 min and consumed a total of 6700 Btu; the conventional oven baked one pan in 12 min and consumed 4200 Btu. Although the conventional oven used less total energy, it consumed 840 Btu per dozen rolls, while the convection oven used only 448 Btu per dozen.

Data of this type, especially when obtained from independent laboratory testing, allows the reader of the brochure to compare the product being advertised to the equipment they currently have or to competitive equipment.

15.2.3 Conclusions Drawn from the Comparison

Energy-saving claims presented in manufacturers' brochures should be substantiated by test results. The results should be printed in the brochure or be readily available from the manufacturer on request. If there are no references on which to base the results in the brochure, the reader should make further inquiries regarding the claims presented.

16.1 Introduction

Nine cooking methods are defined and the most common foods cooked by each method are listed. The pieces of equipment which can be used for each method also are listed and the most energy efficient of these is indicated.

16.2 Baking or Roasting

Baking is the cooking of food in an oven using 'dry heat'. The same cooking method applied to the cooking of meats is known as roasting.(138) Foods that are baked include leavened products* such as cakes, muffins and breads as well as unleavened products such as pies. Roasting is used for large, tender cuts of meat.(139)

Baking and roasting are most commonly performed in conventional ovens where heat is transferred to the food surface by natural convection and radiation. Equal product quality with less energy consumption is achieved with a convection oven. Convection ovens are more energy efficient than traditional ovens because they use forced convection rather than natural convection to transfer the heat to the food.

The 'dry heat' involved in baking and roasting imparts unique flavor and texture characteristics to the food. Baking and roasting, however, are the least energy efficient of all cooking methods.

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* Leavened product is one which is made light and porous with air, steam or a chemical agent (eg. baking powder) capable of producing carbon dioxide.(140)

The amount of energy consumed when baking or roasting can be reduced by:

- Filling ovens to capacity by choosing the smallest oven possible to do the job and by scheduling roasting and baking.
  Reason: The heat lost from an oven depends upon the oven's construction and how the oven is used. Therefore, to reduce the amount of energy used per kilogram of food, the oven must be loaded to capacity.(21)

- Opening the oven door only when necessary during cooking and relying on timers as much as possible.
  Reason: Each second the door is open the oven loses 1% of its heat, resulting in longer cooking times and additional energy usage to raise the oven temperature again.(22)

- Cooking meat slowly at low temperatures.
  Reason: Cooking a roast 5 h at 120°C (250°F) will save 25 to 50% of the energy that would be required to cook the meat 3 h at 180°C (350°F).(25) Lower temperatures mean that the heat transfer rate through the walls to the surroundings will decrease because of the reduced temperature differential.

- Not wrapping potatoes and other food products in aluminum foil.
  Reason: The foil acts as an insulator, inhibiting efficient transfer from the hot air in the oven to the food.(26,27)

16.3 Boiling and Simmering

Boiling is the cooking of food by immersing it in a liquid heated to the boiling point; that is, the temperature at which vapor is formed and rises continually to the surface of the liquid in the form of bubbles.(141) Simmering occurs when the liquid is at a temperature just below the boiling point. This is characterized by bubbles forming slowly and collapsing below the surface of the liquid.(142)

Foods that are suitable for boiling include vegetables, pasta and eggs in the shell. However, vegetables will have a brighter, fresher appearance and retain more of their nutrient value if steamed. Simmering is used for delicate foods which would break apart if boiled (e.g. fish and poached eggs). Simmering may also be referred to as poaching.

Boiling and simmering are most commonly performed in a pot on a range. Boiling on a range, however, wastes substantial amounts of energy because heat is lost from the pot and the element or burner to the surrounding air. Less energy is used when boiling and simmering are performed in a steam-jacketed kettle or tilting skillet.

The amount of energy consumed when boiling and simmering on a range can be reduced by:

- Using cooking utensils with tight-fitting lids. Reason: The lids reduce heat loss from the food due to convection and evaporation.(61)

- Using cooking utensils made of a good conducting metal and with flat bottoms.
  Reason: Pots made of a material with a high conductance increase the rate of heat transfer from the heat source to the food. Flat bottoms on cooking utensils maximize the contact area with the electric element or hot top, increasing the heat transfer.(61)

- Turning off an electric range a few minutes before cooking is finished.
  Reason: This allows food to finish cooking with the residual heat of the range rather than losing this heat to the surroundings.

The amount of energy consumed when boiling and simmering in steam-jacketed kettles and tilting skillets can be reduced by:

- Closing the cover when heating food to the cooking temperature.
  Reason: Energy use can be reduced by 5 to 10%(106) because less heat is lost to the surroundings.

16.4 Braising

Braising is the cooking of food in a small amount of liquid at a low temperature.(141) The food is covered during the cooking process and may be browned in a small amount of fat before braising.

Poultry and thin, less tender cuts of meat are the foods most commonly cooked by this method. With this 'moist heat' cooking method, less tender cuts of meat can be cooked long enough to tenderize them without the meat cooking dry or scorching.(139)

Braising is most often performed in a pan on a range. However, range cooking wastes substantial amounts of energy. Therefore, braising should be carried out in a steam-jacketed kettle or in a tilting skillet to conserve energy.

16.5 Broiling

Broiling is cooking food by exposing it to a high temperature heat source.(141) Foods that are broiled include fatty, tender meats, poultry, fish and vegetables.

Broiling is performed in equipment specifically designed for the purpose. The distance the food is placed from the heat source is adjusted depending on the thickness, density and fat covering of the food.(92)

The amount of energy consumed per unit mass of product during broiling depends on the amount of food being cooked at one time. With a partially-covered broiler rack or grid, some of the heat produced is radiated to the surroundings and not used to cook the food.

16.6 Deep Frying

Deep frying is cooking food by immersing it in hot fat or oil.(143) Foods that are suitable for deep frying include potatoes, chicken, fish, seafood, other vegetables, and doughnuts. Deep frying gives food a distinct flavor and often a crisp exterior. Frying is the only cooking method in which the heat transfer medium, the oil, becomes part of the cooked food producing the distinctive eating quality of fried foods.

Deep frying can be carried out in a tilting skillet and in a pot on a range. However, only a deep fryer should be used because exact temperature control is required for safety and acceptable product quality. Fat temperatures which vary as little as 10°C (15°F) may change the flavor of the final product. Tilting skillets are generally considered to be underpowered and too shallow for this cooking method.(104)

The amount of energy consumed when deep frying can be reduced by:

- Draining foods before frying.
  Reason: Energy is required to evaporate excess moisture on the food.(81)

- Thawing foods with long cooking times (e.g. meats) before frying.
  Reason: Energy use increases if the food is fried from the frozen state(82) and the food may burn on the outside while being undercooked in the interior.

16.7 Shallow Frying

Shallow frying is cooking food in a small amount of added hot fat or oil.(143) The temperature is adjusted so the fat is hot enough to brown the food, but not so hot that the fat decomposes or smokes.(144) Foods that are shallow fried include thin, tender cuts of meat, poultry, fish, eggs and vegetables. Shallow frying of vegetables is often referred to as sautéeing or stir-frying.

Food can be shallow-fried in a pan on a range, on a griddle, in a steam-jacketed kettle and in a tilting skillet. Shallow frying on a range wastes energy and should be avoided. A griddle is the most common piece of equipment used for shallow frying. However, a tilting skillet can be used to fry the same foods and it gives equal product quality with less energy use. Shallow frying in steam-jacketed kettles is limited primarily to scrambling eggs, sautéeing vegetables and frying ground beef.

When shallow frying the cooking surface should be covered as completely as possible with food. This reduces heat loss from the cooking surface.(68)

16.8 Steaming

Steaming is cooking food in steam at or above atmospheric pressure.(145) All foods except those requiring a crust or browned appearance can be steamed.(110) Steam-cooked vegetables have a brighter, fresher appearance and retain more of their nutrient value because of the short cooking times.(113) Several different foods can be steamed at the same time because steam does not transfer flavors from one food to another.(114)

Steaming is most efficiently carried out in a steamer. It can also be performed in a pot on a range, in a steam-jacketed kettle and in a tilting skillet if a rack is used to elevate the product above the water. Because cooking on a range wastes substantial amounts of energy compared to using the other pieces of equipment, it should not be used for steaming.

Equipment should be loaded to capacity when steaming to reduce energy consumption; under-filled equipment loses heat to the air above the food.

16.9 Stewing

Stewing is cooking food in a seasoned liquid for a long period of time.(145) The food is covered during the cooking process. Small, less tender pieces of meat and poultry most often are stewed. The long cooking time under 'moist heat' conditions means that the meat can be cooked long enough to be tenderized without the danger of drying or scorching.(141)

Stewing can be accomplished in a pot on a range, in a steam-jacketed kettle or tilting skillet. Since cooking on a range wastes substantial amounts of energy stewing should be done in a steam-jacketed kettle or in a tilting skillet.

17.1 Introduction

Most foods can be prepared by several cooking methods. Each method imparts slightly different appearance, flavor or texture characteristics to the food. Using a variety of cooking methods lends variety to a menu, allowing restaurant customers to make choices depending on their own personal preference.

Each cooking method can be carried out in several pieces of equipment. The quality of the product and the amount of energy consumed depend on the equipment used. Variety in cooking methods is desireable but care must be used when selecting which piece of equipment is used for each cooking method.

The Application Guide recommends the most energy-efficient piece of equipment for cooking foods by specific cooking methods. Equipment is ranked according to energy efficiency. Product quality and ease of preparation also are considered because energy efficiency is of little benefit if product quality is sacrificed. The development of the Application Guide was based on the experience of individual team members and information obtained from research journals and experts in the fields of energy and food science.

Table 17.1 Application Guide - Energy-Efficient Match of Equipment Type to Cooking Method

Product	Cooking Method	Equipment		
		First Choice	Second Choice	Other Choices
1) Breads, Cakes and Related Products	Bake	Convection oven	Microwave oven(1,2)	Conventional oven
	Deep fry	Deep fryer	Tilting skillet	Range
2) Eggs and Egg Dishes	Bake	Convection oven	Microwave oven(2)	Conventional oven
	Boil	Steam-jacketed kettle	Tilting skillet	Range
	Shallow fry	Steam-jacketed kettle	Tilting skillet	Griddle, Range
	Poach	Steamer	Steam-jacketed kettle or Tilting skillet	Range, Microwave oven(2)
3) Fish and Seafood	Bake	Convection oven	Microwave oven(2)	Conventional oven
	Broil	Broiler	--	--
	Deep fry	Deep fryer	Tilting skillet	Range

Table 17.1 Application Guide - Energy-Efficient Match of Equipment Type to Cooking Method

		Equipment		
Product	Cooking Method	First Choice	Second Choice	Other Choices
Fish and Seafood Cont'd.	Shallow fry	Tilting skillet	Griddle	Range
	Poach	Steamer	Tilting skillet	Microwave oven, Range, Conventional oven
4) Main-Dish Casseroles	Bake	Convection oven	Microwave oven(2)	Conventional oven
5) Meat and Poultry	Braise	Tilting skillet	Steam-jacketed kettle	Range
	Broil	Broiler	--	--
	Deep fry	Deep fryer	Tilting skillet	Range
	Shallow fry	Tilting skillet	Steam-jacketed kettle	Griddle, Range
	Roast	Convection oven	Microwave oven(1,2)	Conventional oven

Table 17.1 Application Guide - Energy-Efficient Match of Equipment Type to Cooking Method

Product	Cooking Method	Equipment First Choice	Second Choice	Other Choices
Meat and Poultry Cont'd.	Steam	Steamer	Steam-jacketed kettle	Tilting skillet, Range
	Stew	Steam-jacketed kettle	Tilting skillet	Range
6) Pasta (spaghetti, macaro [illegible] Rice	Boil	Steam-jacketed kettle	Range	--
7) Soups and Sauces	Simmer	Steam-jacketed kettle	Tilting skillet	Range, Microwave oven(2)
8) Vegetables	Bake	Convection oven	Microwave oven(2)	Conventional oven
	Boil	Steam-jacketed kettle	Tilting skillet	Range, Microwave oven
	Broil	Broiler	--	--

Table 17.1 Application Guide - Energy-Efficient Match of Equipment Type to Cooking Method

Product	Cooking Method	Equipment		
		First Choice	Second Choice	Other Choices
Vegetables Cont'd.	Shallow fry	Tilting skillet	Steam-jacketed kettle	Range, Griddle
	Steam	Steamer	Steam-jacketed kettle	Range, Tilting skillet

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[1] Product quality will be less acceptable than when product is cooked in a convection oven.

[2] Microwave oven is best suited to cooking small quantities of product.

18.1 Introduction

The success of a restaurant energy conservation program, depends on employee involvement because the way staff perform their tasks frequently dictates how much energy is used. The planning of a successful energy conservation program must include training. Training is an integral part of a successful energy conservation program.

Employees often resist changes in established food preparation procedures unless they understand the reasons for such changes. Therefore, each kitchen staff member needs to know how and where energy is consumed in the restaurant. For example, the staff should be aware of which pieces of equipment consume energy, how much energy they consume and how the restaurant is billed for energy usage. Whenever possible, employees should know how much energy costs and what portion of the restaurant's total operating costs are related to energy consumption.

18.2 Employee Involvement and Motivation

Staff respond more positively to an energy conservation program if they participate in the work and are asked for ways to save energy. An Energy Management Committee composed of staff from all areas of the restaurant encourages total employee involvement in the program. Energy-saving ideas generated by the staff are usually implemented more quickly and enthusiastically than procedures dictated by management. At the same time, publicizing staff suggestions which are used and the resulting energy savings helps maintain employee motivation and interest in the program.

Special incentive plans are helpful when starting an energy conservation program and they ensure continued interest after the program has been established. Employee contributions to the energy program can be incorporated into reviews of employee performance. In addition, contests with appropriate rewards can be run to provide further motivation. For example, a U.S. hotel chain ran a nine-month competition among 12 of their hotels to determine which hotel could conserve the most energy.(146)

Energy usage in each hotel was measured quarterly and compared to the energy used during the same time period the previous year. The grand prize winner was the hotel which achieved the greatest energy savings over the nine-month period. The hotel with the greatest reduction in energy consumption was declared the winner for the quarter and each employee received a cash reward. The money saved was shared by the employees at the hotel.

18.3 Training Sessions

18.3.1 Introduction

To ensure that staff are properly introduced to energy management, special training sessions are recommended. For example, to emphasize the need for specialized training in energy management, the University of Manitoba presented a one-day pilot Restaurant Energy Management Workshop to restaurant and hotel managers.(147) At this pilot presentation, the restaurant industry indicated it was prepared to spend time and money on energy management. However, training sessions must be adaptable to small and large groups and well-defined information must be presented. The presentation must be given by a qualified individual with teaching skills or by an individual trained in presenting a well-defined audio-visual package with self-explanatory workbooks. Presentations can be made by in-house employees or outside consultants who have been hired to make the presentation.

18.3.2 Methods of Training

The use of a wide variety of teaching techniques (quizzes, demonstrations, visual aids and group discussions) increases participants' interest and allows each segment of the session to be presented by the best method. An example of this is a workshop module package consisting of instructor-student workbooks, slides, film strips, sound cassettes and video tapes (in various combinations). This type of presentation has the greatest potential for transferring energy management technology to the restaurant industry.

Supplementary teaching techniques, such as group discussions, demonstrations and graphs increase the effectiveness of a presentation. A workshop module is especially effective because it is adaptable for use with individuals, small groups or large groups. Portions of the workshop package covering specific topics can be given to individuals requiring instruction in a particular area. For example, a section of the module on energy-efficient use of food preparation equipment would be of interest to chefs and kitchen staff.

Group training sessions are the most efficient way to introduce an energy management program to employees. Group sessions encourage interaction between the instructor and the participants as well as learning through effective discussion. Training in energy-efficient procedures must be an on-going process; new employees can be introduced to the program concepts through individual instruction (e.g. using a portion of a workshop module package).

Once initial training is completed, reminders at the point of operation will make it easier for employees to implement the information learned. For example, colored stickers showing start-up and preheat times can be placed on equipment near switches (Figure 18.1).(148)

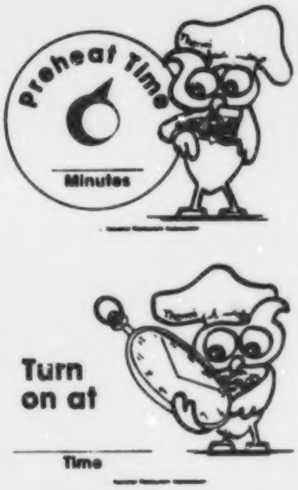
Preheat Time
Minutes
Turn on at
Time

Figure 18.1 Equipment Labels

There are many opportunities to reduce energy consumption in restaurant food preparation. Efficient use of equipment (e.g. scheduling its use, filling it to capacity, minimizing preheating time) saves energy at little or no cost to the restaurant owner. Energy-efficient matching of food preparation equipment to cooking methods also results in no-cost energy savings. Purchasing equipment with energy-saving features reduces energy consumption during the life of the equipment. There is tremendous potential for saving energy during food preparation and it is essential that restaurant owners and employees learn where this potential is.

Specific conclusions drawn from each section of this report are as follows:

1. A restaurant owner must evaluate the local cost of gas and electricity relative to the energy efficiency of a piece of equipment when purchasing new equipment. Because the combustion products from gas-fired equipment are exhausted while they are still hot electric equipment is more energy efficient than gas equipment. However, this does not mean that electric equipment is the least expensive to operate. In many areas of Canada, gas-fired equipment may be less expensive to operate because of the low cost of gas in those areas.

2. Procedures such as those listed in the application sections for each piece of equipment can be followed to reduce the energy consumed by food preparation equipment.

3. Electric ignition systems used in place of pilot lights on gas-fired equipment have the potential to reduce energy consumption. The savings possible with electric ignitions depend on the amount of time the equipment is used. Equipment used only intermittantly benefits more than equipment used almost continuously.

4. Microwave ovens use energy more efficiently than conventional or convection ovens. However, the quality of some food products cooked in microwave ovens may be less than acceptable and the quantities of food which can be cooked at one time is limited.

5. Electric convection ovens or gas-fired convection ovens with recirculation systems produce food of equal quality to that produced by conventional ovens, but with greater energy efficiency.

6. Ranges with individual burners are more energy efficient than those equipped with hot tops because only the area of the range being used is heated.

7. Griddles are versatile and easy to use but are less energy efficient than steam-jacketed kettles or tilting skillets which can be used to perform the same cooking methods.

8. Broilers with infrared burners are more energy efficient than broilers equipped with burner-heated ceramics because they require the shorter preheating times.

9. Pressure steamers are more energy efficient than atmospheric steamers for cooking foods such as

vegetables and fish because steam under pressure contains more heat, resulting in shorter cooking times.

10. Cooking in steam-jacketed kettles is more energy efficient than cooking on a range because the heat transfer process is more efficient.

11. Food-processing equipment uses a negligible amount of energy compared to the total energy consumed in food preparation because most of the energy supplied to this type of equipment is used to run small electric motors.

12. Dishwashers must be correctly sized to avoid wasting hot water.

13. Low-temperature dishwashers save energy when compared to high-temperature models, however, the cost of sanitizing chemicals, drying time and labor must also be considered.

14. The heat extracted from the hot water in a water-cooled refrigerator condensor may be recovered in a heat exchanger to provide additional energy for a hot water system.

15. Energy-saving claims found in manufacturers' brochures must be read carefully to avoid misinterpretation.

16. Baking and roasting are the least energy efficient of all cooking methods, however, they impart unique texture and flavor characteristics to the food and are the only cooking methods possible for certain foods (e.g. cookies).

17. Selection of the correct piece of food preparation equipment for each cooking method saves energy without sacrificing product quality.

18. The success of a restaurant energy conservation program depends on employee involvement. Such a program must be introduced to staff through carefully planned training programs.

20.0 RECOMMENDATIONS FOR FUTURE WORK

1. Seminar material for restaurant owners and employees on energy-efficient equipment, processes and procedures should be developed from the information contained in this report.

2. An investigation should be conducted to compare the energy consumed and the eating quality of foods cooked in preheated and cold-start commercial conventional and convection ovens.

3. Further evaluation of the energy efficiency and costs related to the purchase and operation of low- and high-temperature dishwashers should be undertaken.

4. Data should be compiled on the cost of gas and electricity across Canada to assist restaurant owners in making informed choices between electric and gas-fired equipment.

5. An investigation should be conducted to examine the feasibility of retrofitting electric ignition systems to existing equipment.

6. A study should be conducted to compare the economics of purchasing, operating and maintaining gas-fired and electric fryers.

7. A study should be carried out to establish the effect on product quality of cooking foods in equipment regulated by load-shedding equipment.

8. A study should be conducted to compare the energy consumed by different types of food preparation equipment when cooking the same food.

9. The federal Department of Consumer and Corporate Affairs should be encouraged to develop an EnerGuide program for commercial cooking equipment similar to the one which exists for domestic appliances.

10. The principles discussed in this report should be applied in an existing restaurant. The energy consumption associated with food preparation should be monitored before and after the principles are implemented.

11. Recipes should be developed which incorporate the energy conservation principles discussed in this report.

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Title	The Realities of Microwave Cooking
Author(s)	Anonymous
Publisher/Date/Pages	B.C. Hydro Printing Service/no date/28 pages
Available from/Price	B.C. Hydro Energy Conservation Division Vancouver, British Columbia
Catalogue & Indexing Numbers	PS 20-10-78 (6-80)
Key Words	Energy use/microwave cooking/microwave oven
Sector Applicability	Residential/Restaurant

Abstract	A general description of microwave cooking including safety, energy use, advantages and limitations, buying guidelines, utensils, and cookbooks available.
Critique	This book is written in layman's language and is aimed at the general consumer audience.

Title	G-280 Series Gas Restaurant Range
Author(s)	Anonymous
Publisher/Date/Pages	Garland Commercial Industries, Inc./no date/ 4 pages.
Available from/Price	Garland Commercial Industries, Inc. 1177 Kamato Road Mississauga, Ontario L4W 1X4
Catalogue & Indexing Numbers	Form GRR-M-0177RB
Key Words	Commercial/ranges
Sector Applicability	Restaurant

Abstract	Manufacturer's brochure describing gas-fired ranges
Critique	Brochure describes improvements made in the burners to improve energy efficiency.

Title	Hobart H-600 Mixer
Author(s)	Anonymous
Publisher/Date/Pages	Hobart Canada Inc./no date/2 pages
Available from/Price	Hobart Canada Inc. 190 Railside Road Don Mills, Ontario M3A 1B1
Catalogue & Indexing Numbers	HC7599(778/1R1181)
KeyWords	Mixers
Sector Applicability	Restaurant

Abstract	Manufacturer's brochure on model H-600 mixer.
Critique	Brochure describes features of the mixer, dimensions and capacity.

Title	Conservador Superior Strip Doors
Author(s)	Anonymous
Publisher/Date/Pages	Randall Industries/no date/3 pages
Available from/Price	Randall Industries 685 Executive Drive Hinsdale, Illinois 60521
Catalogue & Indexing Numbers	Not applicable
Key Words	Energy conservation/door strips/refrigeration
Sector Applicability	Restaurant

Abstract	Manufacturer's brochure describing plastic door strips used on walk-in coolers and freezers to reduce energy consumption. The manufacturer claims savings in electric bills of 30-45%.
Critique	The claims made in the brochure are not backed by research data.

Title	ASHRAE Handbook and Product Directory - 1977 Fundamentals
Author(s)	Anonymous
Publisher/Date/Pages	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)/1977/756 pages
Available from/Price	ASHRAE 345 East 4th Street New York, NY 16017
Catalogue & Indexing Numbers	Not applicable
Key Words	Air-conditioning/heating/refrigeration/ventilation
Sector Applicability	All

Abstract	Includes the theory and basic data essential for equipment development, system design and application. The book is divided into six sections: 1) theory 2) general engineering data, 3) basic material, 4) load calculations, 5) duct and pipe sizing, 6) general.
Critique	This is the most comprehensive source of reference data on air-conditioning, heating, ventilation and refrigeration. The theory section is useful for anyone involved in energy conservation.

Title	Pitco High-Efficiency Frialtors - The Uncomplicated Fryers
Author(s)	Anonymous
Publisher/Date/Pages	J.C. Pitman Company Inc./1978/5 pages
Available from/Price	J.C. Pitman Co., Inc. P.O. Box 501 Concord, New Hampshire 03301
Catalogue & Indexing Numbers	P-1589 A
Key Words	Deep fryer/fryer/gas fryer
Sector Applicability	Restaurant

Abstract	Manufacturer's brochure describing series of gas-fired deep fryers.
Critique	Brochure describes 30% energy cost savings achieved with these fryers. Fryers have a cool zone which collects burnt particles and crumbs, reducing fat breakdown and taste transfer.

Title	The MJCF Chicken and Fish Fryer
Author(s)	Anonymous
Publisher/Date/Pages	The Frymaster Corporation/1978/1 page
Available from/Price	Garland Commercial Ranges, Ltd. 1177 Kamato Road Mississauga, Ontario L4W 1X4
Catalogue & Indexing Numbers	Bulletin No. 818-0026
Key Words	Deep fryer/fryer/gas fryer
Sector Applicability	Restaurant

Abstract	Manufacturer's brochure describing a gas-fired deep fryer specifically designed for frying breaded products.
Critique	The fryer has a large cold zone which collects crumbs and sediment from the frying area. These particles are trapped in the cold zone where they do not carbonize, contaminate the shortening or cling to the fried foods.

Title	Handbook of Food Preparation
Author(s)	Anon.
Publisher/Date/Pages	American Home Economics Association/1980/152 pages.
Available from/Price	American Home Economics Association 2010 Massachusetts Avenue, N.W. Washington, D.C. 20036 $7.00
Catalogue & Indexing Numbers	ISBN 0-8461-1417-8
Key Words	Cookery/food/food preparation
Sector Applicability	Restaurant/Residential

Abstract	A handbook covering all aspects of food preparation, buying, preservation, freezing, and storage.
Critique	An excellent reference for anyone working in the area of food preparation.

Title	Motivating Employees to Save Energy
Author(s)	Anonymous
Publisher/Date/Pages	Lodging/1980/2 pages
Available from/Price	American Hotel Association Directory Corp. 888 Seventh Avenue New York, NY 10019
Catalogue & Indexing Numbers	March issue, pp. 27-28
Key Words	Energy/foodservice employees/motivation
Sector Applicability	Restaurant

Abstract	Article in a trade journal describing methods used by a management company to help a hotel chain motivate employees to conserve energy. Article also describes results of the main method used, a contest between hotels in the chain.
Critique	A good practical example of a motivation technique.

Title	Meltmaster Plus II - Electric Cheesemelter MM-48 Series
Author(s)	Anonymous
Publisher/Date/Pages	Lang Manufacturing Company/1981/2 pages
Available from/Price	Lang Manufacturing Company 9040 Willows Road P. O. Box 905 Redmond, Washington 98052
Catalogue & Indexing Numbers	L-274
Key Words	Broiler
Sector Applicability	Restaurant

Abstract	Manufacturer's brochure describing energy-saving features, outstanding features and specifications.
Critique	Brochure does not contain data to back-up claims made.

Title	Vulcan Gas Convection Oven-Snorkel Model
Author(s)	Anonymous
Publisher/Date/Pages	Vulcan-Hart Corporation/1981/4 pages
Available from/Price	Vulcan-Hart Corporation 3600 North Point Blvd., Baltimore, Maryland
Catalogue & Indexing Numbers	GCO-86/81
Key Words	Convection ovens/gas-fired/recirculation system
Sector Applicability	Restaurant

Abstract	Manufacturer's brochure on convection ovens with a snorkel (recycling) tube.
Critique	Brochure includes theory on how the snorkel tube improves the energy efficiency of the oven. Also includes information on the various models available and the features available on each model.

Title	Waste Heat Recovery as Applied to Restaurants and Restaurant Energy Conservation
Author(s)	Anonymous
Publisher/Date/Pages	University of Manitoba/1981/114 pages
Available from/Price	Office of Industrial Research Department of Mechanical Engineering Room 230, Engineering Bldg. University of Manitoba R3T 2N2
Catalogue & Indexing Numbers	Not applicable
Key Words	Energy Conservation/heat exchangers/heat recovery
Sector Applicability	Restaurant

Abstract	A study to classify Canadian restaurants according to their type and energy usage and to evaluate the potential for energy conservation in each category. Restaurant energy audits showed major differences in energy consumption between each of the selected restaurant categories. Practical methods of reducing restaurant energy consumption were established.
Critique	Thirty-five (35) Winnipeg restaurants were surveyed and energy audits conducted. Energy consumption records were obtained from the electric and gas utility companies. Manitoba Hydro provided detailed electrical demand data for several of the restaurants. A significant portion of the project examined ways to reduce energy usage associated with the exhaust ventilation and the potential for exhaust air heat recovery.

Title	Blodgett Convection Oven with Dual Flow Fan System
Author(s)	Anonymous
Publisher/Date/Pages	G. S. Blodgett Co., Inc./1982/4 pages
Available from/Price	G. S. Blodgett Co., Inc. P.O. Box 586 Burlington, Vermont 05402
Catalogue & Indexing Numbers	BL-666
Key Words	Convection oven/gas-fired/recirculation system
Sector Applicability	Restaurant

Abstract	Manufacturer's brochure describing a gas-fired convection oven with a recycling fan.
Critique	Brochure describes the theory on how the recycling fan improves the energy efficiency of the oven. Also describes other features of the oven.

Title	Energy Management System Stickers
Author(s)	Anonymous
Publisher/Date/Pages	National Restaurant Association/1982
Available from/Price	Technical Services Department National Restaurant Association One IBM Plaza, Suite 2600 Chicago, Ill. 60601
Catalogue & Indexing	T5101 PP-14M282
Key Words	Energy management/energy record keeping
Sector Applicability	Restaurant

Abstract	The Energy Management System package consists of a simple record-keeping system and includes a set of stickers to be used as energy-saving reminders.
Critique	The package describes no-cost methods for reducing energy consumption in a restaurant.

Title	Restaurant Technology Support Program Task 4 Report: Restaurant Energy Workshop
Author(s)	Anonymous
Publisher/Date/Pages	University of Manitoba/1982/92 pages
Available from/Price	Office of Industrial Research Room 230, Engineering Bldg. University of Manitoba Winnipeg, Manitoba R3T 2N2
Catalogue & Indexing Numbers	Not applicable
Key Words	Energy conservation/technology transfer
Sector Applicability	Restaurant

Abstract	The task was an investigation into the effectiveness of transferring energy conservation technology to the restaurant industry through workshop presentations.
Critique	The report clearly demonstrates that technology transfer to the restaurant industry can be successful through workshop demonstrations.

Title	1983 Annual Listing-Food Service Equipment
Author(s)	Anonymous
Publisher/Date/Pages	National Sanitation Foundation/January 1, 1983/ 251 pages
Available from/Price	National Sanitation Foundation NSF Building 3475 Plymouth Road P. O. Box 1468 Ann Arbor, Michigan 48106
Catalogue & Indexing Numbers	Not applicable
Key Words	Cooking equipment/food service/restaurants
Sector Applicability	Restaurant

Abstract	Complete listing of all food service equipment that fulfills the requirements of a National Sanitation Foundation standard. Listing is 1) alphabetically by company 2) according to equipment by standard met.
Critique	The book is a useful reference for capacities and power requirements of available equipment.

Title	MJH50 Series Fryers
Author(s)	Anonymous
Publisher/Date/Pages	The Frymaster Corporation/1983/7 pages
Available from/Price	Garland Commercial Ranges, Ltd. 1177 Kamato Road Mississauga, Ontario L4W 1X4
Catalogue & Indexing Numbers	Bulletin No. 818-0064 4/83
Key Words	Deep fryer/fryer/gas fryer
Sector Applicability	Restaurant

Abstract	Manufacturer's brochure describing a new series of gas-fired deep fryers.
Critique	The fryers have: 1) an open frypot-no tubes 2) built-in filtering system 3) deep cold zone 4) built-in frying computer. The manufacturer claims an efficiency of 74% and a flue temperature of approximately 650°F.

Title	Energy Consumption and Quality of Foods Cooked in Preheated and Cold-start Ovens.
Author(s)	Valerie Allen-Spragge
Publisher/Date/Pages	Master's Thesis/1983/243 pages
Available from/Price	University of Manitoba Winnipeg, Manitoba R3T 2N2
Catalogue & Indexing Numbers	Allen-Spragge, V.J., 1983
Key Words	Cold-start oven/energy consumption/food/preheating/quality
Sector Applicability	Residential/Restaurant

Abstract	Twenty-nine products were baked under preheated and cold-start conditions in two electric ovens. Cooking time, eating quality, energy consumption, percent moisture and cooking losses were examined. Results showed that energy savings from 10 to 33% could be achieved with cold-start cooking depending on the oven used.
Critique	An extensive study which looked at a wide variety of food products.

Title	Comparison of Reduced Ascorbic Acid Content of Microwave and Conventional Cooked Fruits and Vegetables - Final Report
Author(s)	Gertrude Armbruster
Publisher/Date/Pages	Thermador/Waste King Division of Norris Industries/ 1978/7 pages
Available from/Price	Thermador/Waste King 5119 District Blvd. Los Angeles, CA 90040
Catalogue & Indexing Numbers	Not applicable
Key Words	Ascorbic acid/conventional cooking/fruits/ microwave cooking/vegetables
Sector Applicability	Residential/Restaurant
Abstract	Report of a research study which evaluated the ascorbic acid content of fruits and vegetables after cooking by microwave, conventional and convenient methods. In 18 of 24 instances studied the ascorbic acid content of the microwave cooked product was significantly higher than that of the other two methods. Microwave cooking times were significantly shorter than conventional cooking times.
Critique	A very comprehensive study.

Title	A Modern Guide to Foodservice Equipment
Author(s)	Arthur C. Avery
Publisher/Date/Pages	CBI Publishing Company, Inc./1980(a)/351 pages
Available from/Price	CBI Publishing Company, Inc. 51 Sleeper Street Boston, Massachusetts 02210
Catalogue & Indexing Numbers	ISBN 0-8436-2179-6
Key Words	Cooking equipment/foodservice
Sector Applicability	Restaurant

Abstract	A guide to foodservice equipment including descriptions, specifications, sizing, basic use and operation, cleaning and maintenance and special applications. A separate chapter is devoted to saving energy.
Critique	A complete guide suitable for use as a textbook or as a guide for chefs and managerial personal.

Title	Bringing Energy Efficiency to Griddles
Author(s)	Arthur C. Avery
Publisher/Date/Pages	Institutions/April 1980 (b)/3 pages
Available from/Price	Arthur C. Avery Professor, Restaurant, Hotel & Institutional Management Purdue University Lafayette, Indiana 47909
Catalogue & Indexing Numbers	Vol. 86, No. 7, pp. 79-82
Key Words	Energy efficiency/griddles
Sector Applicability	Restaurants

Abstract	Journal article discussing how to manage the use of energy in griddle operations. Also discusses capacity determination, griddle testing and griddle utilization.
Critique	The article presents many useful ideas on energy conservation based on the author's many years of experience in the industry.

Title	Making the Most of the Versatile Tilting Frypan
Author(s)	Arthur C. Avery
Publisher/Date/Pages	Institutions/1980 (c)/2 pages
Available from/Price	Arthur C. Avery Professor, Restaurant, Hotel & Institutional Management Purdue University Lafayette, Indiana 47907
Catalogue & Indexing Numbers	Vol. 86, No. 2, pp. 49-50
Key Words	Braising pan/energy consumption/tilting frypan/tilting skillet
Sector Applicability	Restaurant

Abstract	Journal article describing what cooking operations a tilting frypan can be used for, how to determine capacity requirements and energy-saving procedures.
Critique	The author of the article has more than 15 years experience in the foodservice industry. Article gives useful ideas on using the tilting frypan in an energy-efficient way.

Title	Foil Wrap in Oven Cooking
Author(s)	M. R. Baity, A. E. Ellington and M. Woodburn
Publisher/Date/Pages	Journal of Home Economics/1969/3 pages
Available from/Price	School of Home Economics Purdue University Lafayette, Indiana 47907
Catalogue & Indexing Numbers	Vol. 61, No. 3, pp. 174-176
Key Words	Beef loaves/cooking time/foil wrap/oven cooking
Sector Applicability	Residential/Restaurant

Abstract	Journal article describing the effect of different foil wrap for ground beef loaves. The study looked at the cooking patterns of meats with and without the use of foil at 200°F and 450°F. At 450°F the foil acted as a heat shield which decreased the effective cooking temperature and increased the cooking time.
Critique	Well-conducted study.

Title	Electrical Energy Used and Time Consumed When Cooking Foods by Various Home Methods: Chickens
Author(s)	R. C. Baker, J. M. Darfler and G. E. Rehkugler
Publisher/Date/Pages	Poultry Science/1981/9 pages
Available from/Price	R. C. Baker Department of Poultry and Avian Sciences Cornell University Ithaca, New York 14853
Catalogue & Indexing Numbers	Volume 60, pp. 2062-2070
Key Words	Broiler cooking/cooking time/electrical energy/energy used/home methods
Sector Applicability	Residential/Restaurant

Abstract	Broilers and fowl were cooked by various home methods and the electrical energy and time required for cooking were recorded. Results indicated that energy used in cooking chicken can best be conserved by: 1) using the smallest appliance for the task 2) minimizing moisture loss by covering the utensil and/or a short cooking time or 3) using the microwave oven.
Critique	Although the study only looks at one product a wide variety of cooking methods were examined.

Title	Marks' Standard Handbook for Mechanical Engineers
Author(s)	T. Baumeister, E. A. Avallone, T. Baumeister III (ed.)
Publisher/Date/Pages	McGraw-Hill Book Company/1978/1700 pages
Available from/Price	McGraw-Hill Book Company New York, NY $100.00
Catalogue & Indexing Numbers	ISBN 0-07-004123-7
Key Words	Heat transfer/materials/refrigeration
Sector Applicability	All

Abstract	The handbook is intended to supply the practicing engineer with a reference which is authoritative in character and which covers the field of mechanical engineering in a comprehensive manner.
Critique	This is an excellent resource for mechanical engineers as well as anyone involved in detailed energy conservation studies.

Title	The Science of Food
Author(s)	Marion Bennion
Publisher/Date/Pages	Harper & Row Publishers, Inc./1980/598 pages
Available from/Price	Harper & Row Publishers, Inc. 10 East 53rd Street New York, NY 10022 $35.00
Catalogue & Indexing Numbers	ISBN 0-06-453532-0
Key Words	Carbohydrates/flour products/food/food preservation/food safety/proteins
Sector Applicability	Residential/Restaurant

Abstract	Textbook which emphasizes the chemical and physical structure of food and the effects of processing and preparation on its properties.
Critique	Research studies are frequently cited in this basic text making it an excellent resource book.

Title	Conventional Roasting vs. High-Temperature Foil Cookery - Effect on Cooking Time, Palatability, Weight Loss and Fuel Consumption.
Author(s)	G. G. Blaker, J. L. Newcomer and W. D. Stafford
Publisher/Date/Pages	Journal of the American Dietetic Association/1959/ 5 pages
Available from/Price	School of Hotel, Restaurant and Institutional Management Michigan State University East Lansing, Michigan 48823
Catalogue & Indexing Numbers	Vol. 35, pp. 1255-1259
Key Words	Conventional roasting/cooking time/foil cookery/fuel consumption/palatability
Sector	Residential/Restaurant

Abstract	Journal article describing a study which compared the quality and weight loss of top round beef and ready-to-eat hams cooked at 350°F in a conventional oven, with and without being wrapped in aluminum foil. Fuel consumption and cooking times were also recorded. Little time saving for wrapped beef roasts or hams. Fuel consumption was greatly increased when meat was wrapped in foil (483 cu. ft. vs 916 cu. ft. for ham and 500 cu. ft. vs. 800 cu. ft. for beef). The insulating effect of foil was equivalent to lowering the oven temperature 75°F.
Critique	Study is limited to two types of meat, but the conclusive results likely mean they can be extrapolated to all meats.

Title	Food Science
Author(s)	Helen Charley
Publisher/Date/Pages	John Wiley & Sons/1982/564 pages
Available from/Price	John Wiley & Sons Inc. New York, N.Y. $35.00
Catalogue & Indexing Numbers	ISBN 0-471-06206-5
Key Words	Cookery/food/nutrition
Sector Applicability	Residential/Restaurant

Abstract	Presentation of scientific concepts as a basis for understanding foods as complex chemical systems. Includes a chapter on "Heating and Cooling Foods" (Chapter 3).
Critique	Chapter on "Heating and Cooling Foods" includes a discussion of the process of energy transfer as it applies to cooking in home appliances.

Title	Economies of Steam Cooking
Author(s)	Gil Cummings
Publisher/Date/Pages	Restaurant Business/1978/3 pages
Available from/Price	Bill Communications Inc. 633 Third Avenue NewYork, NY 10017
Catalogue & Indexing Numbers	Vol. 77, No. 5, pp. 83, 84 & 87
Key Words	Energy conservation/steam cooking/steamers
Sector Applicability	Restaurant

Abstract	Journal article describing the major advantages of steam cooking: 1) improved food quality 2) less energy consumption. The article describes the advantages of convection and pressure steamers.
Critique	The article contains little detail, but is a brief overview.

Title	Fuel Consumption by Cooking Appliances
Author(s)	F. Drew and K. S. Rhee
Publisher/Date/Pages	Journal of the American Dietetic Association/1978/ 8 pages
Available from/Price	Ki Soon Rhee Dept. of Animal Science Texas Agricultural Experimental Station Texas A & M University College Station, TX 77843
Catalogue & Indexing Numbers	Vol. 72, pp. 37-44
Key Words	Cooking appliances/energy/fuel consumption
Sector Applicability	Residential/Restaurant

Abstract	Journal article comparing the energy consumption of a microwave oven, slow cooker, electric skillet, oven broiler, electric conventional oven, gas conventional oven and liquid petroleum conventional oven when cooking meat loaves, beef patties and beef roasts. The eating quality of the products was also examined. The electric conventional oven consumed more energy than did the other appliances. Microwave oven used less energy than other appliances to cook a beef patty, but as the load increased (beef loaf or roast) the differences declined sharply. Energy savings for baking in a microwave rather than a conventional oven were 95%, 52% and 45% for cooking a beef patty, a meatloaf and a beef roast, respectively.
Critique	Extensive, well-conducted study.

Title	Heating Prepared Foods from Frozen and Thawed States: Acceptability and Energy Consumption
Author(s)	Food Advisory Division
Publisher/Date/Pages	Unpublished study/1982/17 pages
Available from/Price	Food Advisory Division Agriculture Canada Ottawa, Ontario K1A 0C5
Catalogue & Indexing Numbers	Not applicable
Key Words	Acceptability/energy consumption/frozen foods
Sector Applicability	Residential/Restaurant

Abstract	A study examining the effect of heating prepared foods from thawed and frozen states on acceptability and energy consumption. Four food items were cooked from frozen and thawed states. There was no significant difference in acceptability between the frozen and thawed samples, but heating from the thawed state required 14 - 48% less energy than heating from the frozen state.
Critique	Although the study looked at only four food items the results have implications for generally thawing frozen food before cooking, especially when the food has long cooking times.

Title	A Comparison of Energy Use in Cooking Appliances
Author(s)	Virginia Gries
Publisher/Date/Pages	Pacific Gas and Electric Company/1976/30 pages
Available from/Price	Pacific Gas and Electric Company San Francisco, California 94106
Catalogue & Indexing Numbers	Not applicable
Key Words	Cooking appliances/domestic/energy
Sector Applicability	Residential/Restaurant

Abstract	A report of research done by PG & E on the energy consumption of domestic cooking appliances. Cooking appliances studied included ovens, ranges, and microwave ovens. Both gas and electrical appliances were compared. Research included an investigation into the energy-saving possibilities of cooking in cold-start ovens.
Critique	Research was an extensive investigation of the subject area and included several models of each type of equipment.

Title	Fundamentals of Heat Transfer
Author(s)	H. Grober and S. Erk
Publisher/Date/Pages	McGraw-Hill Book Company/1961/526 pages
Available from/Price	McGraw-Hill Book Company, Inc. New York, NY
Catalogue & Indexing Numbers	Library of Congress Catalog Number 60-53219
Key Words	Heat transfer
Sector Applicability	All sectors

Abstract	A basic textbook explaining the fundamentals of heat transfer.
Critique	This text is written primarily for advanced mechanical engineering students. Calculus is used extensively in the explanations.

Title	Commercial Cooking Equipment Improvement-Annual Report
Author(s)	R. L. Himmel
Publisher/Date/Pages	Gas Research Institute/1981/51 pages
Available from/Price	Gas Research Institute 8600 West Bryn Mawr Avenue Chicago, Illinois 6063.
Catalogue & Indexing Numbers	GRI-80/0080
Key Words	Cooking equipment/gas-fired
Sector Applicability	Restaurant
Abstract	Report describes efforts at improving the efficiency of gas-fired commercial cooking equipment. Discusses work on deep fryers, range oven sections, range open top sections, range fry top sections. Improvements in direct-fired convection ovens resulted in a reduction in energy consumption of 55%. Modifications to range hot top sections demonstrated fuel savings of 43%.
Critique	A good summary of individual research projects carried out by the American Gas Association from January to December 1980. Essential reading for anyone concerned with the design or manufacture of commercial gas appliances.

Title	Commercial Cooking Equipment Improvement - Volume 1: Range Ovens
Author(s)	R. L. Himmel and R. E. Stack
Publisher/Date/Pages	American Gas Association/October 1981/23 pages
Available from/Price	Gas Research Institute 8600 West Bryn Mawr Ave. Chicago, Illinois, 60631
Catalogue & Indexing Numbers	GR1-80/0079.1
Key Words	Appliances/cooking/efficiency/equipment/natural gas/ovens/ranges
Sector Applicability	Restaurant

Abstract	The report describes the efforts of a project aimed at improving the operating efficiency of gas-fired commercial cooking equipment, specifically hotel and restaurant heavy duty range ovens.
Critique	This is a research report and very technical in nature. It is well written and complete.

Title	Thermodynamic Properties of Steam
Author(s)	J. H. Keenan and F. G. Keyes
Publisher/Date/Pages	John Wiley and Sons, Inc./1966/89 pages
Available from/Price	John Wiley and Sons, Inc. New York, N.Y.
Catalogue & Indexing Numbers	Not available
Key Words	Steam/thermodynamics
Sector Applicability	Industrial/Residential/Restaurant

Abstract	Complete set of tables and Mollier diagram for the thermal properties of steam
Critique	An old but still valuable reference.

Title	Energy Requirements for Cooking Beef Rib Roasts
Author(s)	B. M. Korschgen, J. M. Berneking and R. E. Baldwin
Publisher/Date/Pages	Journal of Food Science/1980/2 pages
Available from/Price	B. M. Korschgen Dept. of Food Science and Nutrition University of Missouri - Columbia Columbia, Missouri 65211
Catalogue & Indexing Numbers	Volume 45, pp. 1054-1055
Key Words	Beef roasts/eating quality/energy consumption
Sector Applicability	Residential/Restaurant

Abstract	Journal article comparing the energy requirements to cook beef rib roasts by four cooking methods. The four methods were: 1) in a conventional oven at 163 ± 3°C 2) in a conventional oven using a high-temperature-interrupted method 3) in a portable oven broiler at a 'slow' setting 4) in a microwave oven on HIGH for first half of the cooking time and on ROAST for the second half. The conventional method consumed 77% as much energy as either method 2) or 3). Microwave cooking represented a 27% saving in energy compared to the conventional method on a Wh/kg basis.
Critique	Study results focus on only one cut of beef, although they cover four cooking methods.

Title	Nutrition Aspects of Microwave Cooking
Author(s)	G. E. Livingston
Publisher/Date/Pages	Microwave Energy Applications Newsletter/1979/ 5 pages
Available from/Price	Microwave Energy Applications Newsletter P. O. Box 241 Amherst, New Hampshire 03031
Catalogue & Indexing Numbers	Vol. XII, No. 5, pp. 4-9
Key Words	Microwave cooking/nutrition
Sector Applicability	Residential/Restaurant

Abstract	Overview article discussing research which looked at the nutritional aspects of microwave cooking from 1948 to 1979. Articles discussed compared nutrient losses in microwave cooking with those occurring in other cooking methods.
Critique	An excellent review article.

Title	Energy Efficient Cooking Systems for Muscle Foods
Author(s)	R. W. Mandigo and T. J. Janssen
Publisher/Date/Pages	Food Technology/1982/6 pages
Available from/Price	University Microfilms International 300 North Zeeb Road Ann Arbor, Michigan 48106
Catalogue & Indexing Numbers	Vol. 36, No. 4, pp. 128-133
Key Words	Energy/muscle foods
Sector Applicability	Residential/Restaurant

Abstract	Journal article including a report on a study done at University of Nebraska investigating the energy usage of a foodservice microwave oven, a forced-air convection oven and a rotary-hearth still-air electric oven when cooking three types of fresh pork (sausage links, roasts, chops). The microwave and convection ovens saved energy because less warm-up time was required than for the electric oven. Convection oven consumed significantly less energy than the electric oven. Microwave oven used significantly less energy than the electric oven.
Critique	Article is a comprehensive overview of research done on energy-efficient ways of cooking meat both at the consumer and the foodservice level.

Title	Energy Consumption: A Comparison Between the Microwave and the Conventional Electric Range
Author(s)	D. R. McConnell
Publisher/Date/Pages	Journal of Microwave Power/1974/7 pages
Available from/Price	D. R. McConnell Amana Refrigeration Inc. Amana, Iowa 52203
Catalogue & Indexing Numbers	Vol. 9, No. 4, pp. 341-347
Key Words	Conventional range/energy consumption/microwave oven
Sector Applicability	Residential/Restaurant

Abstract	Journal article comparing the energy consumption of 77 food items prepared in a microwave oven and a self-cleaning electric range. The microwave oven consumed less energy for 57 of the 77 items with a medium saving of 63%.
Critique	An extensive study looking at a wide variety of food products. Sixty-seven of the items prepared were in three to four person servings and 10 items were in single-serving sizes.

Title	Maximize Your Equipment Potential
Author(s)	Maureen McKenna
Publisher/Date/Pages	School Food Service Journal/1982/2 pages
Available from/Price	Maureen McKenna, Manager Education Services Market Forge Everett, Massachusetts
Catalogue & Indexing Numbers	Vol. 36, No. 5, pp. 82 & 84
Key Words	Energy consumption/equipment/steam cooking/steamers
Sector Applicability	Restaurant

Abstract	Journal article describing the advantages of steam cooking in terms of time and energy consumptions. The article describes the different types of steamers and what they should be used for.
Critique	A brief article giving some general ideas on energy saving with steam cooking.

Title	Reducing Energy Loss in Foodservice Operations
Author(s)	Lucy M. McProud
Publisher/Date Pages	Food Technology/July, 1982/5 pages
Available from/Price	Lucy M. McProud Assistant Professor Dept. of Nutrition and Food Science San Jose State University San Jose, California 95192
Catalogue & Indexing Numbers	Vol. 36, No. 7, pp. 67-71
Key Words	Convection ovens/energy loss/foodservice/oven preheating
Sector Applicability	Restaurant

Abstract	Journal article which investigated whether cooking food without preheating a gas-fired forced convection oven would save energy and still produce a product of acceptable quality. Beef loaves were cooked in a preheated and nonpreheated convection oven at 163°C. Significantly more energy was used in the preheated than nonpreheated oven, resulting in energy savings of 14% (6000 Btu). Beef loaves in preheated and nonpreheated ovens had similar yields and only slight differences in color and overall acceptability scores.
Critique	Although the study was limited to only one product (beef loaves) and involved a specific convection oven it shows the potential for energy savings when convection ovens are not preheated. It is something all foodservice managers can investigate further in their own operations.

Title	Effects of Oven Preheating on Energy Consumption, Eating Quality and Baking Time of Selected Baked Products
Author(s)	Vicki McTaggart
Publisher/Date/Pages	Canadian Home Economics Journal/1980/3 pages
Available from/Price	Micromedia Limited 144 Front Street, West Toronto, Ontario M5J 1G2
Catalogue & Indexing Numbers	Vol. 31, No. 4, pp. 211-213.
Key Words	Eating quality/energy consumption/oven preheating
Sector Applicability	Residential/Restaurant

Abstract	Ten common baked products were prepared and baked in a preheated and nonpreheated oven. Energy consumption was recorded on a watthour meter. Eating quality of each product was evaluated by 40 untrained judges in subsequent trials. Baking in a nonpreheated oven saved 3 to 22% of the energy used when baking in a preheated oven. Judges reported no differences in eating quality due to treatment in 6 of the 10 products.
Critique	Although the study was limited to one category of food products, baked goods, it demonstrated the potential for energy savings by baking in nonpreheated ovens.

Title	Comparison of Energy Consumption Between the Microwave Oven and the Conventional Electric Range
Author(s)	Vicki McTaggart
Publisher/Date/Pages	Canadian Home Economics Journal/1982/3 pages
Available from/Price	Micromedia Limited 144 Front Street, West Toronto, Ontario M5J 1G2
Catalogue & Indexing Numbers	Vol. 32, No. 1, pp. 32-34.
Key Words	Electric range/energy consumption/microwave oven
Sector Applicability	Residential/Restaurant

Abstract	Journal article comparing the energy consumption of four common foods cooked in a conventional electric oven, on a surface element and in a microwave oven. Complete two- and six-serving meals were also prepared and cooked by the three methods. Energy consumption was measured by a watthour meter. Quantity of food and cooking time affected the amount of energy required to cook the food by the various methods. Conventional oven used more energy than the other methods. For small quantities of food the microwave oven was the most energy efficient.
Critique	Complete study which showed how the piece of equipment used for a cooking method has a distinct effect on the energy consumed. The amount of food cooked was also an important factor in energy consumption.

Title	Energy Builders
Author(s)	Carol Michael
Publisher/Date/Pages	Foodservice Journal/1978/4 pages
Available from/Price	Carol Michael Instructor Dept. of Home Economics Miami University Oxford, Ohio 045056
Catalogue & Indexing Numbers	Vol. 32, No. 2, pp. 36-39
Key words	Appliance/energy/foodservice
Sector Applicability	Restaurant

Abstract	Article describing how foodservice equipment can be used and maintained to conserve energy. The article discusses steam equipment, deep fryers, griddles, ranges, ovens, refrigerators, freezers, hot water heaters and dishwashers.
Critique	Extensive article with many practical, no-cost ideas to save energy.

Title	Energy Management and Energy Consideration Practices for the Foodservice Industry
Author(s)	National Restaurant Association
Publisher/Date/Pages	NRA/1977
Available from/Price	National Restaurant Association Kansas City, Kansas
Cataloguing & Indexing Numbers	Project No. 3985-D
Key Words	Foodservice/Energy management
Sector Applicability	Restaurant

Abstract

Critique

Title	Food Theory and Applications
Author(s)	Pauline C. Paul and Helen H. Palmer
Publisher/Date/Pages	John Wiley & Sons, Inc./1972/797 pages
Available from/Price	John Wiley & Sons, Inc. Toronto, Ontario
Catalogue & Indexing Numbers	ISBN 0-471-67250-5
Key Words	Food
Sector Applicability	Residential/Restaurant

Abstract	A basic university textbook which presents the chemical and physical basis of food preparation.
Critique	An excellent general reference book on the theory of food preparation. Extensively referenced . Written by various authors who are specialists in their area.

Title	Energy Consumption and Acceptability: Comparison of Cooking Methods and Appliances for Beef Patties
Author(s)	Ki Soon Rhee and Flowayne Drew
Publisher/Date/Pages	Home Economics Research Journal/June 1977/13 pages
Available from/Price	Ki Soon Rhee Department of Animal Science Texas Agricultural Experimental Station Texas A & M University College Station, TX 77843
Catalogue & Indexing	Vol. 5, No. 4, pp. 269-282
Key Words	Acceptability/beef patties/cooking methods/ energy consumption
Sector Applicability	Residential/Restaurant

Abstract	Beef patties were cooked by pan frying, broiling, baking and microwave heating to determine the fuel consumption and the sensory characteristics of the cooked products. Pan frying and microwave cooking were comparable and cost the least, followed by broiling and baking, respectively.
Critique	Well-conducted research study.

Title	Energy Management in the Kitchen
Author(s)	Dr. Frank Romanelli
Publisher/Date/Pages	Club Management/1978/2 pages
Available from/Price	Dr. Frank Romanelli Executive Manager Anderson Mayfair Properties University of Texas System Cancer Center Houston, Texas
Catalogue & Indexing Numbers	October issue; pp. 34-35.
Key Words	Clubs/energy management/institutions/restaurants
Sector Applicability	Restaurant

Abstract	Journal article giving guidelines to assist club managers in developing guidelines for management control of energy resources. Includes a technique for estimating kW.h consumption of electrical food service equipment by measuring the on-time of the thermostat signal light.
Critique	The technique for estimating kW.h consumption of equipment has possible practical applications for restaurant owners.

Title	Handbook of Energy Conservation for Mechanical Systems In Buildings
Author(s)	Robert W. Roose (Senior Editor)
Publisher/Date/Pages	Van Nostrand Reinhold Company/1978/592 pages
Available from/Price	Van Nostrand Reinhold Company 450 West 33rd Street New York, NY 10001
Catalogue & Indexing Numbers	ISBN 0-442-27012-7
Key Words	Buildings/energy conservation/mechanical systems
Sector Applicability	All

Abstract	Book is designed to aid in the application of the principles and practices of energy conservation in all types of buildings. The areas of design, installation, operation and maintenance of heating, piping, air-conditioning and ventilating systems are discussed.
Critique	The book was written by a wide variety of authors who are specialists in their fields of energy conservation in new and existing buildings.

Title	Food Equipment Facts - A Handbook for the Foodservice Industry
Author(s)	C. Scriven and J. Stevens
Publisher/Date/Pages	John Wiley & Sons/1982/430 pages
Available from/Price	John Wiley & Sons Toronto, Ontario $21.50
Catalogue & indexing Numbers	ISBN 0-471-86819-1
Key Words	Cooking equipment/institutions/restaurants
Sector Applicability	Restaurant

Abstract	A listing of the food preparation equipment available to restaurants and institutions. Includes information about dimensions, power input, preheating times, production capability and options available.
Critique	Listing is very complete for the time of printing. Useful publication for purchasing agents, food service managers and restaurateurs

Title	Energy Management in Foodservice
Author(s)	Nan Unklesbay and Kenneth Unklesbay
Publisher/Date/Pages	AVI Publishing Company/1982/437 pages
Available from/Price	AVI Publishing Company, Inc. Westport, Connecticut $38.00
Catalogue & Indexing Numbers	ISBN 0-87055-403-4
Key Words	Energy conservation/equipment/food service
Sector Applicability	Restaurant

Abstract	Comprehensive approach to energy management in foodservice facilities whereby five energy-managerial policies are adopted. Topics covered in the book include 1) a general overview of energy conservation in the food service industry 2) basic energy principles 3) energy use in refrigeration 4) energy use in ovens 5) energy use in fryers, steamers, broilers, & griddles 6) heating, ventilation and air-conditioning 7) sanitation 8) lighting 9) energy accounting systems 10) implementing energy conservation programs.
Critique	A necessary reference for anyone working in energy conservation in foodservice. A very complete book on the subject. Some references given but no extensive referencing.

Title	The Complete Book of Cooking Equipment
Author(s)	Jule Wilkinson
Publisher/Date/Pages	CBI Publishing Company, Inc./1981/259 pages
Available from/Price	CBI Publishing Company, Inc. 51 Sleeper Street Boston, Massachusetts 02210
Catalogue & Indexing Numbers	ISBN-0-8436-2186-9
Key Words	Equipment/food service
Sector Applicability	Restaurant

Abstract	Gives information on the selection, purchasing, operation and care of foodservice equipment. Emphasis is placed on the need to select, operate, and care for equipment to save energy.
Critique	Information is specific to certain foods and ignores others. A good amalgamation of cooking and equipment data.

Atmospheric steamer	A steamer which has an unpressurized cooking cavity and relies on natural convection to carry the steam to the food.
Baking	Cooking food in an oven using 'dry heat'.
Boiling	Cooking food by immersing it in a liquid heated to the boiling point. This is characterized by bubbles which rise continually and break on the surface of the liquid.
Braising	Cooking food in a small amount of liquid at a low temperature. The food is covered during the cooking process and may be browned in a small amount of fat before braising.
Broiler	A piece of equipment which cooks food by exposing it to a high-temperature heat source.
Broiling	Cooking food by exposing it to a high-temperature heat source.
Char broiler	A broiler with the heat source located under a heavy grid allowing the fat to drip through. The fat burns when it contacts the heat source, giving the same effect as cooking over open coals. Also referred to as an underfired broiler.
Choke seal	An aluminum channel which traps and dissipates microwaves in a microwave oven.
Cold-start cooking	Cooking by placing food in a piece of equipment, setting the temperature desired, then turning the equipment on.

Combustion efficiency	The ratio of the amount of energy output by a gas burner or electric element to the actual amount of energy contained in the quantity of fuel used.
Conduction	The transfer of heat from one particle of matter to another, usually by molecular collision.
Convection	The transfer of heat from one place to another by moving fluids.
Convection oven	An oven which improves upon natural convection by mechanically forcing air through the cooking cavity with a fan. Also referred to as a mechanical oven or a forced convection oven.
Convection steamer	A steamer which uses forced convection in an unpressurized cooking cavity to carry the steam to the food.
Conventional oven	An oven in which natural convection and not mechanical devices (e.g. fans) causes air movement. Also referred to as a natural convection oven.
Conveyer dishwasher	A dishwasher which uses a conveyer to move racks of dishes through the machine. The dishes are washed, rinsed and sanitized in one chamber or in separate chambers.
Cook-to-order	Raw or precooked food prepared to the state of doneness requested by a customer. Cooking does not commence until the order is placed.

Deep fryer	A floor- or bench-mounted cooking unit heated by gas or electricity with a kettle of fat into which food is immersed for cooking. Also referred to as a fryer.
Deep frying	Cooking food by immersing it in hot fat or oil.
Dielectric constant	A mathematical term used to express the dielectric properties of a substance
Dielectric properties	Those properties of a substance which determine how well it absorbs microwaves.
Dishwasher	A piece of equipment which washes, rinses and sanitizes dishes. It may or may not dry the dishes.
Disposer	A piece of equipment which grinds and flushes food waste into the sewage system.
Dry heat cooking	Cooking without the addition of moisture.
Electric element	A metal tube containing a resistance heating wire embedded in a ceramic-filled core.
Fat	A solid or liquid shortening used for shallow and deep frying. The shortening can be either a 100% vegetable product or an animal/vegetable mixture.
Flight dishwasher	A dishwasher with a long conveyer extending out both ends of the machine where dishes are continuously loaded and dried. Washing, rinsing and sanitizing take place continuously in separate chambers.

Forced convection	The transfer of heat from one place to another as a result of fluid motion caused by mechanical means such as a fan or a blower.
Griddle	A thick steel plate with a polished top surface heated by gas or electricity. The surface edges are raised or the unit has grease troughs and a drain hole leading to a catch trough or pan.
Grill	A cooking unit with two heated plates between which the food is placed. The two plates simultaneously cook the top and bottom of the food.
Heat labile vitamins	Vitamins which are destroyed or chemically altered by heat to a form that can no longer function as a vitamin in the body (Vitamine C and thiamine).
Heat transfer efficiency	The ratio of the amount of heat used to cook the food to the amount of heat produced by the gas burner or electric element.
Horizontal broiler	A broiler which uses an overhead or top heat source in a cooking cavity; the front may be open or equipped with a door. Also referred to as an over-fired broiler.
Hot top	A range with a large steel plate instead of individual burners for a cooking surface. Also referred to as a boiling plate or a uniform heat top.
Infrared waves	Invisible heat rays with wavelengths longer than those of red light but shorter than those of micro-waves; that is, between 60μm and 1 mm in length.

Leavened product	A baked product made light and porous with air, steam or a chemical agent (eg. baking powder) capable of producing carbon dioxide.
Low-temperature dishwasher	A dishwasher which rinses dishes with water at 60°C (140°F) containing a chemical sanitizing agent.
Maillard reaction	A nonenzymatic browning reaction which occurs when a complex is formed between the aldehyde groups of reducing sugars and the amino groups of proteins.
Microwave	A very short electromagnetic wave between common radio waves and light waves in wavelength; that is, between 1 and 100 cm in length.
Microwave oven	An oven which cooks food by exposing it to high-frequency electromagnetic waves.
Overall efficiency	The ratio of the heat needed to cook the food to the actual amount of energy contained in the fuel used.
Pressure steamer	A steamer which cooks food at pressures between 35 and 100 kPa (5 to 15 psi).
Radiation	The transfer of heat by electromagnetic waves.
Range	A unit with a solid top surface or individual burners to heat utensils in which foods are cooked.
Reconstitute	To heat frozen or chilled foods to serving temperature.
Recycling fan	A fan which draws air from two sources and exhausts it to one location.

Recycling tube	A tube through which hot combustion products are drawn into the cooking cavity, providing direct heat for cooking.
Ring burner	A gas burner; the air required for combustion enters around and through the center of a ring.
Roasting	Cooking meat in an oven using 'dry heat'.
R-value	The thermal resistance value of a material. The higher the R-value, the better the resistance to heat transfer.
Salamander	A smaller version of the standard heavy-duty overhead broiler; the salamander is located over the back of a range. Also referred to as a backshelf broiler.
Shallow frying	Cooking food in a small amount of hot fat or oil.
Simmering	Cooking food by immersing it in a liquid at a temperature just below the boiling point. This is characterized by bubbles forming slowly and collapsing below the surface of the liquid. Also referred to as poaching when used to cook fish or eggs.
Specialty broiler	An overhead broiler with added features such as a rotating spit.
Specific heat	The amount of heat required to raise the temperature of a unit mass of a product by 1°.
Star burner	A gas burner; the air required for combustion enters through the center of the burner and around both sides of the gas ports.

Stationary rack dishwasher	A dishwasher where the washing, rinsing and sanitizing operations take place in the same chamber.
Steaming	Cooking food in steam at or above atmospheric pressure.
Steam-jacketed kettle	A kettle with live steam introduced between the inner and outer shell. The steam heats the inner shell where food is cooked. Also referred to as a steam kettle.
Steamer	An enclosed cabinet with one or more sealed compartments into which steam is introduced for cooking or heating food.
Stewing	Cooking food, covered, in a seasoned liquid for a long period of time.
Stir-frying	Cooking over high heat in a small amount of fat, using continuous tossing motions.
Tempering	The layer of fat imbedded in the pores of a metal cooking surface which prevents food from sticking.
Tilting skillet	A rectangular-shaped, flat-bottomed kettle with four continuous vertical sides. The bottom is heated by gas burners or electricity. Also referred to as a tilting frypan or tilting griddle.
Warm-up time	The time required for each component of a piece of equipment to reach the desired operating temperature. Also referred to as preheat time.